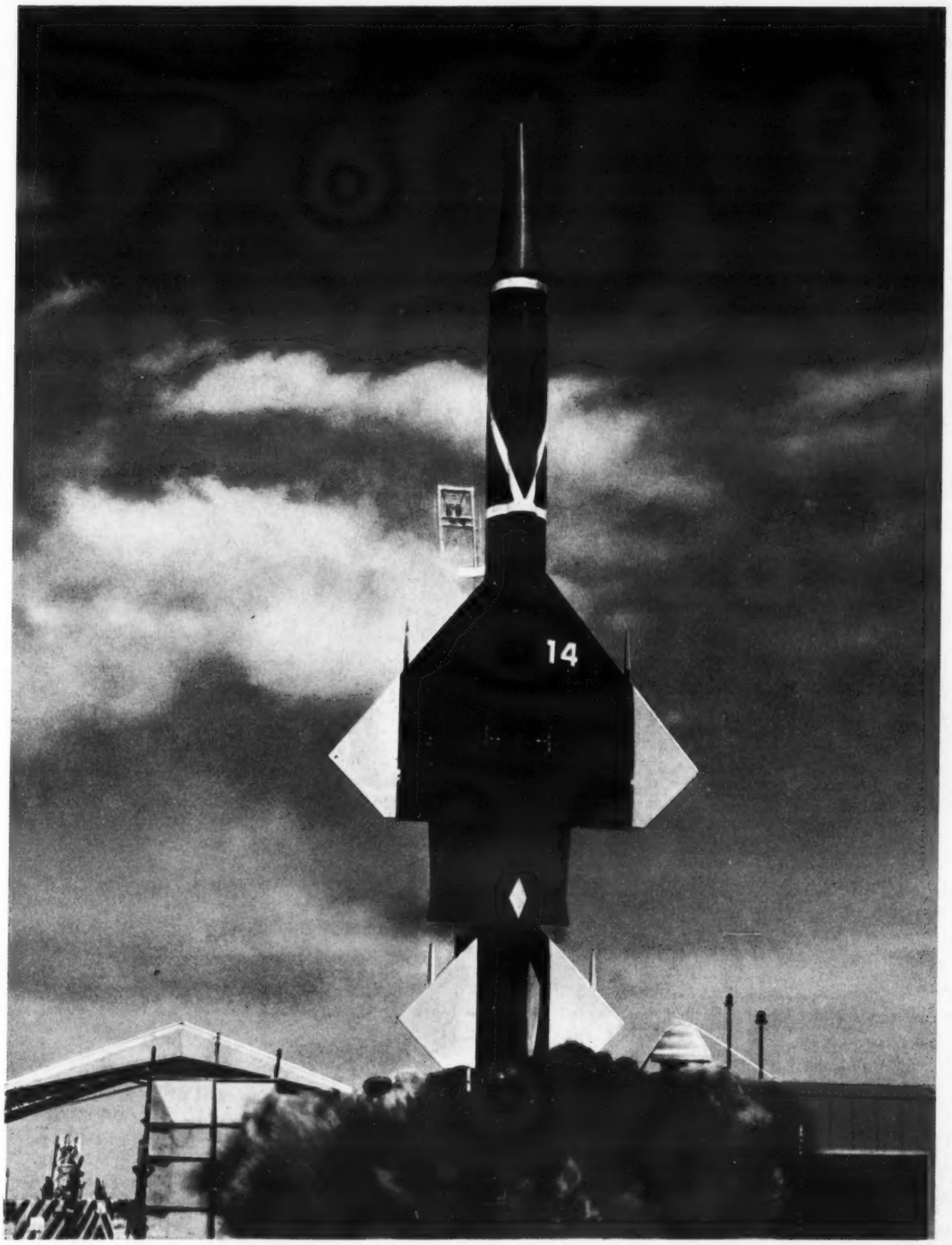
INTERAVIA

World Review of Aviation and Astronautics
with Electronics Supplement



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Long Runways... For How Long?

The V/STOL Solution

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VOLUME XV

No. 5 / 1960

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Volume XV

INTERAVIA

May 1960

WORLD REVIEW OF AVIATION AND ASTRONAUTICS

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Front cover : Launching the Boeing IM-99 *Bomarc* unmanned VTO interceptor.

Among the obligations of an airline the comfort of passengers is second only to their safety.

Sabena is proud of the achievement of one of its engineers, Mr. François Braun, who has designed a new type of seat. This has been built in the company's workshops and put through the most rigorous tests; it increases not only the comfort of travellers, but also their safety. The Braun seat automatically assumes a horizontal position when subjected to a given deceleration, particularly in the case of a hard landing.

The Belgian Aeronautical Administration has recently certificated this new seat. During laboratory tests at Haren, near Brussels, a resistance to deceleration stress of 20 g was recorded, corresponding to 3,750 lb per passenger.

The Braun seat, which will equip the first-class cabins of Sabena's Boeing Intercontinentals, has also aroused the interest of Air France, which has ordered seven lots of 36 seats.

The USAF is also considering using the Braun seat, which it will shortly be subjecting to dynamic tests.

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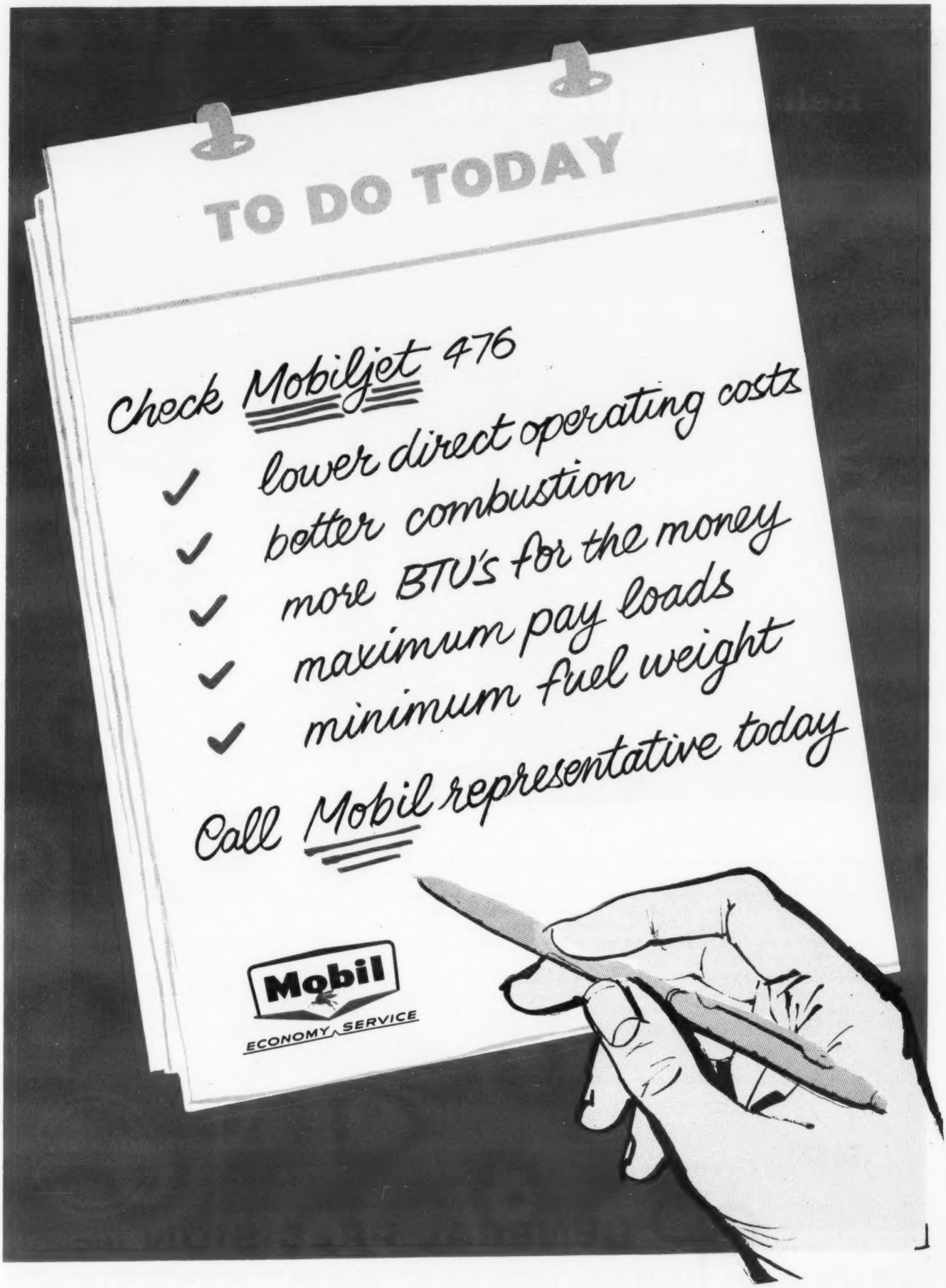
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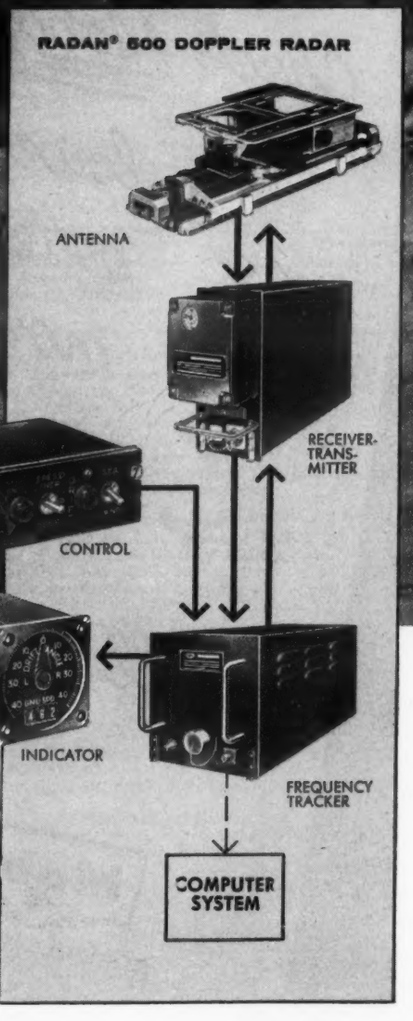

RADAN 500 Doppler radar, GPL's all new ARINC system for airlines, offers the reliability and longevity of service that only 13 years of direct Doppler experience can insure...reliability resulting from **flight-proven** designs based on 10 years of product improvement programs, service feedback on more than 1,500 operational GPL Doppler systems, and special attention to the design and maintenance philosophies of commercial airlines.

SELF-CONTAINED: Ground speed and drift angle, displayed directly, continuously, and accurately — over the poles, over oceans, over any terrain, day or night, good weather or bad — provide a dramatic extension of airline capabilities and important operational savings.

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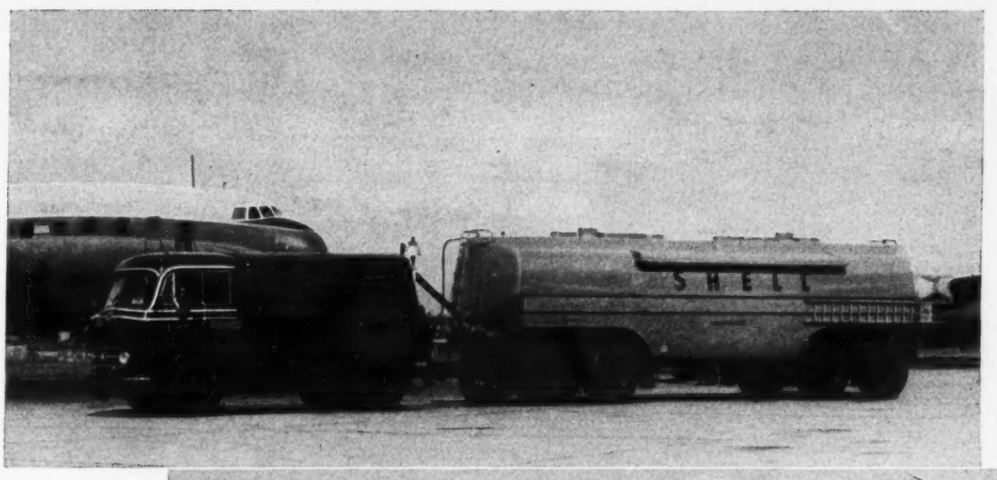

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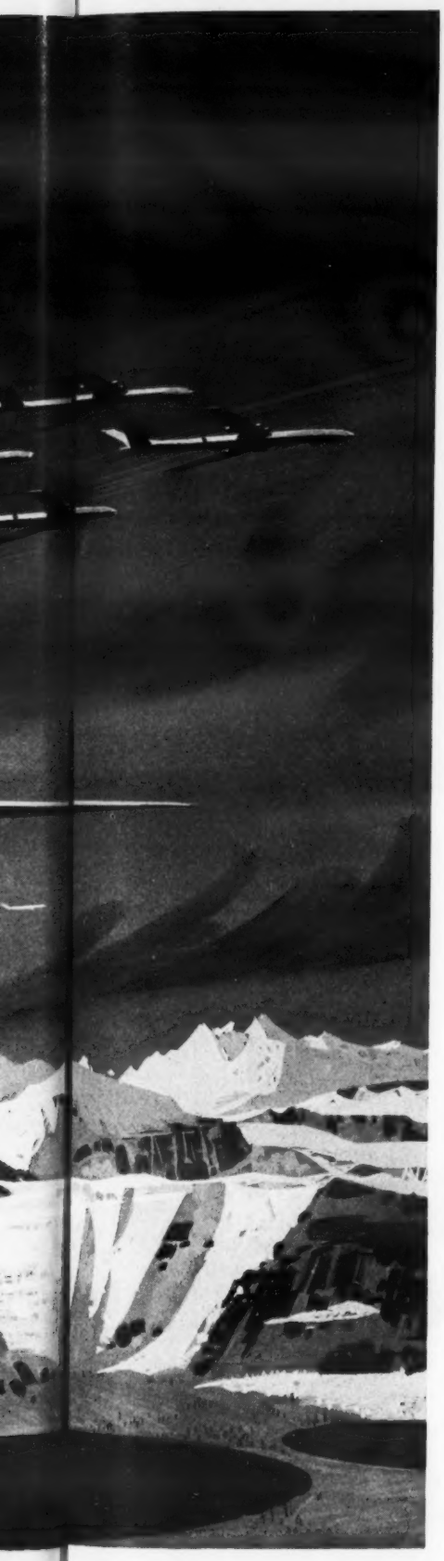


PROBLEM: AIR TRAFFIC CONTROL

In ten seconds these aircraft, flying at jet speeds, will create an entirely new tactical picture. How do you keep track of hundreds of them at the same time?

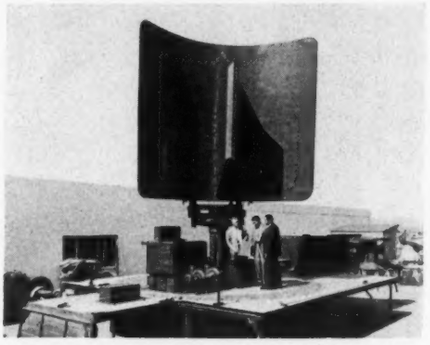
The Hughes Aircraft Company has solved this problem with a unique and highly advanced digital computer. This computer simultaneously tracks large numbers of aircraft and provides three-dimensional coordinate and velocity information on them.

The computer provides extrapolated position data to the observer several times each second. In addition, it measures the position and reports velocity changes every few seconds for each of a large number of targets.

Advanced semiconductor circuitry is utilized throughout the computer. The outputs to the displays are made through high-speed digital to analog converters capable of providing an accuracy of one part in ten thousand—and within 10×10^{-6} seconds.

Combining the latest techniques in packaging and subminiaturization, the computer unit has been designed as a mobile system which withstands rigorous field use.

Systems and devices developed and manufactured by Hughes Aircraft Company cover virtually every electronic field: air-to-air guided missiles, advanced airborne control systems, space ferries, ground-control-radar surveillance systems, microwave communications systems and many others. Commercial products include: diodes, transistors, rectifiers, traveling wave tubes and direct-view storage tubes. The reliability and operational capabilities of Hughes systems and components have earned them the confidence of thousands of users throughout the free world.



This 3-D RADAR ANTENNA, together with advanced data processing units, forms a FRESCANAR System, with the ability to coordinate the firepower of a complex of guided missile batteries. Able to serve large defense zone areas, this Hughes Aircraft Company system greatly extends the capabilities of present-day armament.

TARAN is an aircraft electronic system with Tactical Attack Radar and Navigation features. Lightweight and compact, the TARAN system is easily adapted to a variety of aircraft. TARAN accommodates radar and infrared guided missiles, guns, rockets and bombs.

For further information please write to Hughes International, a Division of Hughes Aircraft Company, Culver City, California, U.S.A.

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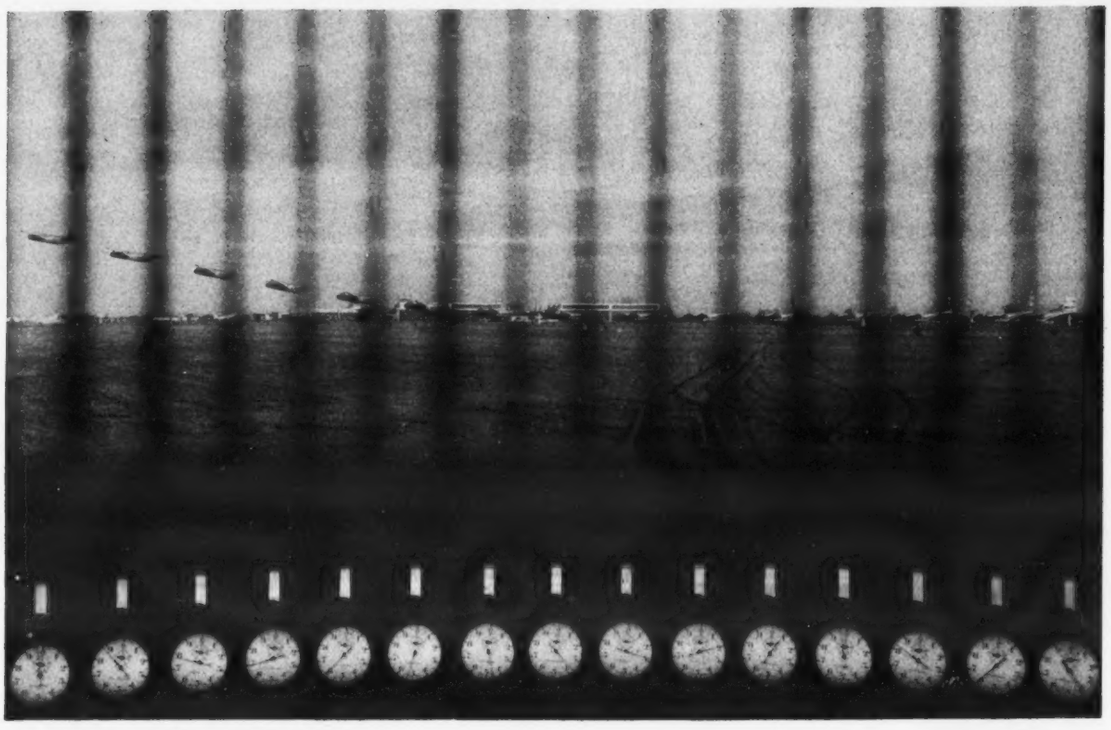
the Caribou is STOL!



PROOF OF THE CARIBOU'S REMARKABLE SHORT TAKE-OFF PERFORMANCE IS RECORDED BY THE UNERRING EYE OF THE CAMERA IN THIS OFFICIAL FLIGHT TEST PHOTOGRAPH.

Conditions were: Airport elevation, 514 ft. MSL. Temperature, −1°C. Wind 2.8 mph. Load, 25,840 lbs. TAKE-OFF GROUND ROLL WAS 460 FEET IN 9.3 SECONDS. DISTANCE OVER A 50 FT. OBSTACLE WAS 910 FT. IN 14.2 SECONDS.

The Caribou
Designed and built by
DE HAVILLAND AIRCRAFT OF CANADA
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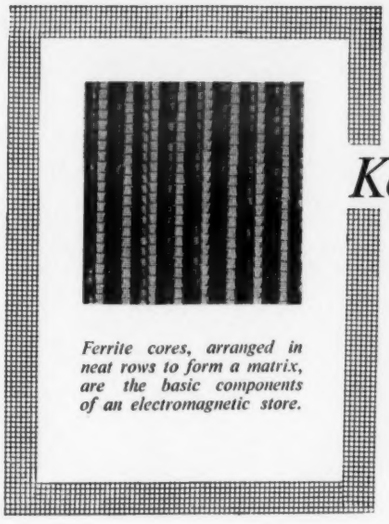

Ferrite cores, arranged in neat rows to form a matrix, are the basic components of an electromagnetic store.

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What's behind this overwhelming preference? The answer is Goodyear engineering leadership, dating back to 1909 when Goodyear built the first airplane wheel. It has produced wheels of the greatest strength and longest life per pound of metal. And it pioneered the famous Goodyear Disc Brake, which brought more efficient braking to scores of fields.

The latest Goodyear advances include the Tri-Metallic Brake, and forged aluminum and magnesium wheels – all unmatched for dependability and weight-savings.

Whatever the aircraft–the right wheel and brake combination is available from Goodyear, *first choice for 50 years!* For full details, call the Goodyear Office near you or write to: Goodyear International Corporation, Aviation Products Division, Akron 16, Ohio, U.S.A.

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SFIM DEVELOPS ONERA TELEMETRY EQUIPMENT

In tests of missiles of all sizes and single-seat military aircraft, the basic flight parameters must be transmitted over long distances and recorded graphically, photographically and magnetically on the ground; the test engineer must also be provided with visual presentation.

O.N.E.R.A. (Office National d'Etudes et de Recherches Aéronautiques) has designed and developed a complete VHF telemetry chain.

S.F.I.M. has now acquired the licence to manufacture this equipment. The firm studies, develops and produces its various component systems and operates the mobile receiver and recording stations on behalf of the users.

S.F.I.M. telemetry equipment is now in current use by the French Navy, the Government Flight Test Centre, G.A.M.D., Nord-Aviation, Sud-Aviation, etc., and has played its part in a number of comparative tests made by the automobile industry.

Main characteristics: 5 channels operating continuously and simultaneously.
Passing band: 400 c/s

Frequency in the 100 Mc/s and 250 Mc/s bands.

Component units:

Airborne:
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- 15-channel commutator, passing band per channel 10 c/s

On the ground:
- receiver
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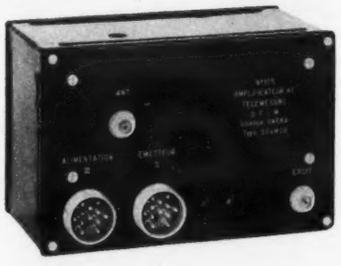
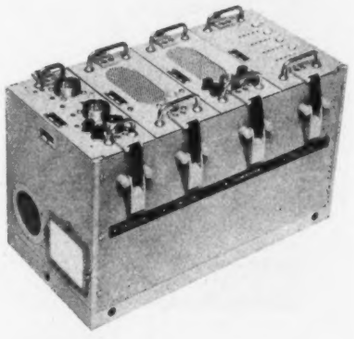
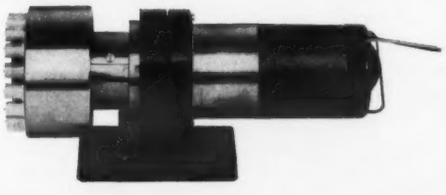
- decoding cabinet
- photographic recorder







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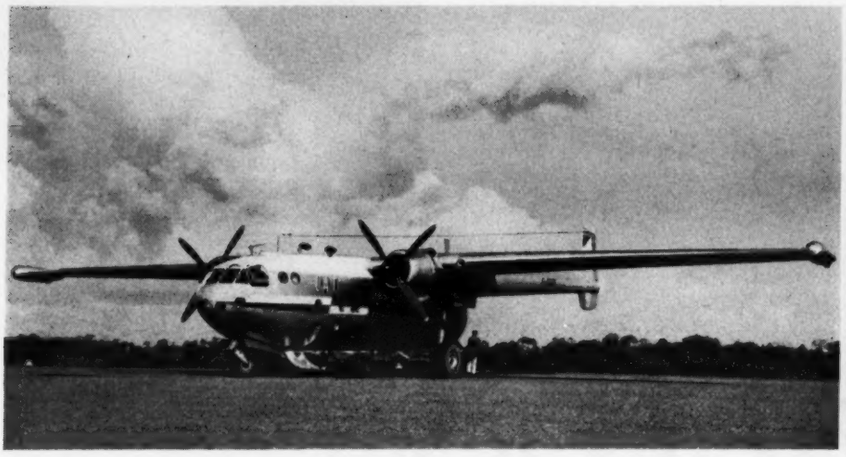

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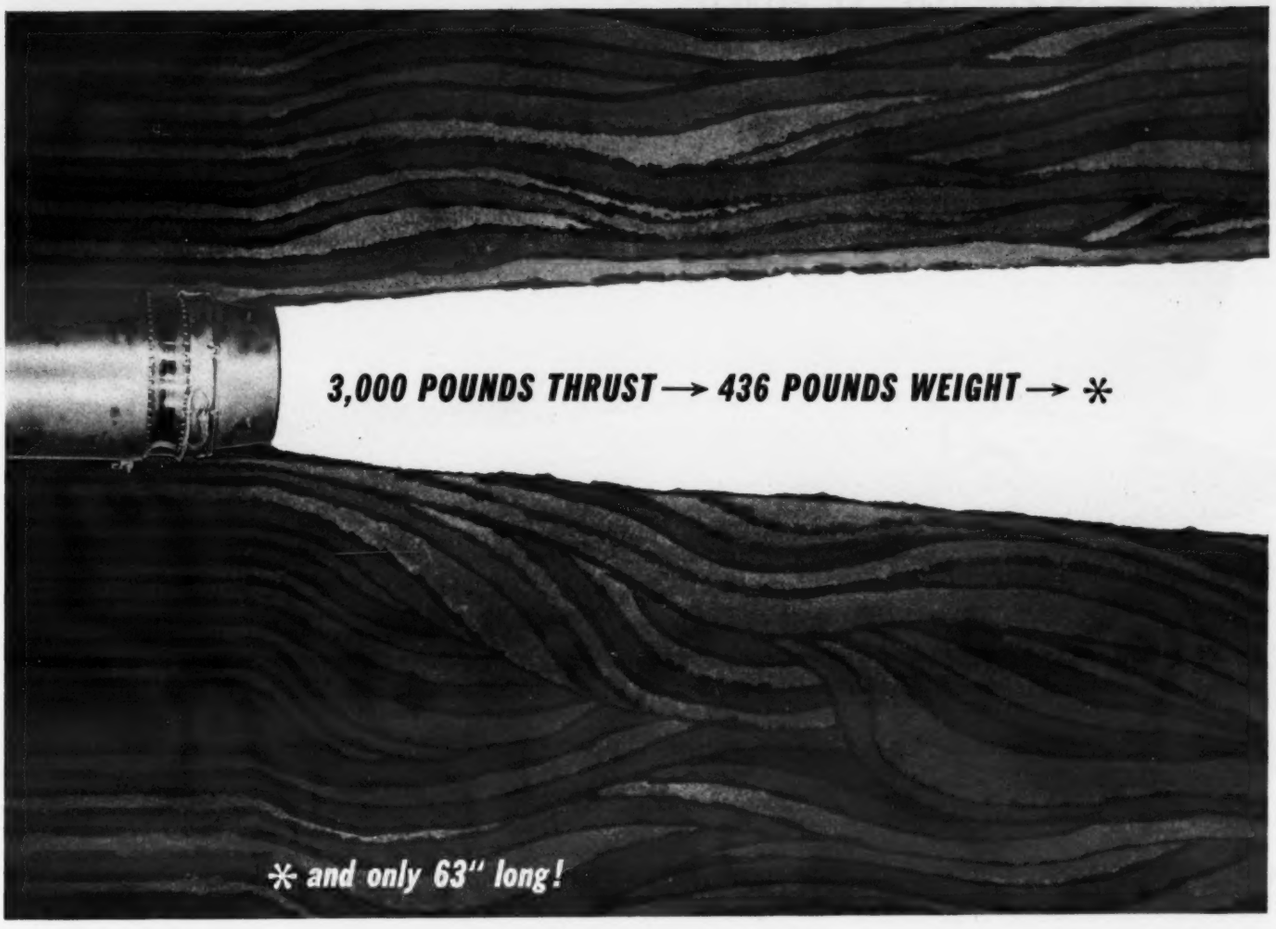

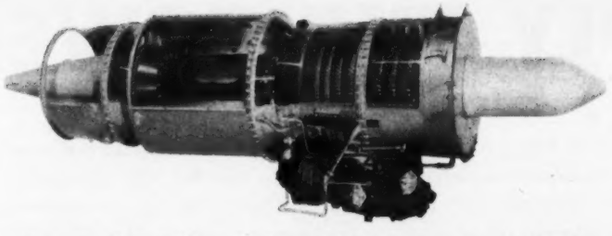

New Pratt & Whitney Aircraft JT12 jet engine is built around proven design concepts for high thrust to weight ratio, ruggedness, reliability and low maintenance.

The JT12 delivers powerful thrust in comparison to the light weight of the engine itself. At maximum cruising speed the thrust specific fuel consumption is only .890. A new jet engine designed on a proven principle, the JT12 is an axial-flow, medium-pressure-ratio turbojet. Behind the JT12 stands all the research, manufacturing and testing facilities that produced the renowned Pratt & Whitney Aircraft J-57 and J-75 designs—the new standards of aircraft engine reliability in commercial jet transportation. Because of the sound basic design of the JT12 and its relatively simple construction, it's an outstandingly reliable and easily maintained engine. The JT12 now powers such aircraft as the Lockheed JetStar transport, the North American Sabreliner and the Canadair CL-41 military trainers, and two U. S. Army drones. Today, the JT12 is establishing new flight performance records of its own.

Pratt & Whitney Aircraft engines are backed by a world-wide network of service representatives.

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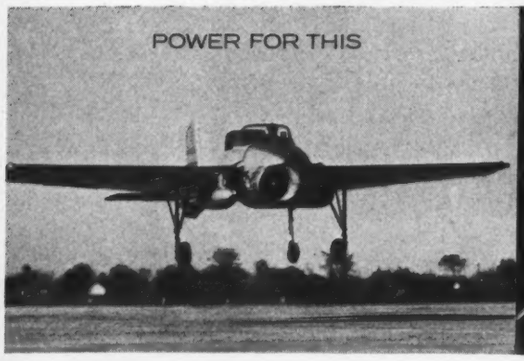
New Italian jet trainer caters for the whole range of training—from primary to advanced techniques

...AND BRISTOL SIDDELEY SUPPLY THE POWER

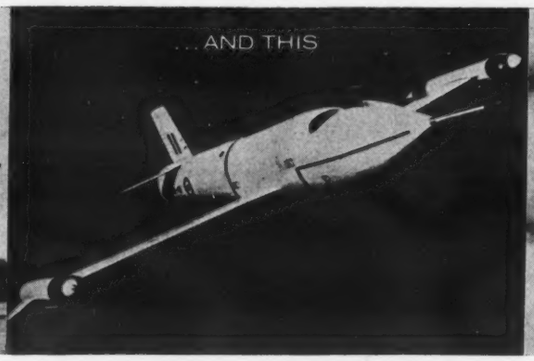
Bristol Siddeley Engines Limited produce the Viper. A turbojet in the 1,700 to 3,000-lb thrust class, the Viper has proved itself in service to have those qualities which are particularly desirable in powerplants for trainer aircraft: great robustness and reliability; indifference to mishandling; and a long overhaul life.

The aeroplane illustrated above is the Italian Macchi MB 326 which has been chosen by the Italian Air Force for both primary and advanced training. The Bristol Siddeley Viper 11 is rated at 2,500-lb thrust but is endurance tested at 2,700 lb and gives the MB 326 outstanding performance flexibility: full aerobatic training at 15,000 to 25,000 ft; navigational training at 25,000 to 40,000 ft; a rate of climb of 4,420 ft/min; and the ability to operate at Mach 0.8. The Macchi MB 326, powered by the Bristol Siddeley Viper 11, is a training aircraft which gives both docile low-speed handling and suitable high-speed characteristics for complete "all through" tuition from the elementary to the advanced stages.

BRISTOL SIDDELEY ENGINES LIMITED



The Bristol Siddeley Viper 8 powers the Bell X 14, VTOL research aircraft.



The Bristol Siddeley Viper 11 powers the Australian Jindivik Mk 3 target drone.

The Bristol Siddeley Viper 8 powers the Hunting Jet Provost trainer.

INTERAVIA AIR LETTER reports...*

The de Havilland Blue Streak, Britain's ballistic missile, has been abandoned as a military weapon, though the possibility of adapting it for space research, perhaps in conjunction with other European countries, is under consideration. This was announced in the House of Commons in mid-April by Defence Minister Harold Watkinson, who said that, even with underground launching silos, static missile sites are too vulnerable. The Government had decided to switch to the Douglas GAM-87A *Sky Bolt* air-launched ballistic missile, to be purchased from the United States. The *Polaris* IRBM for mobile launching from submarines had also been considered, but the overall cost would be prohibitive.

Direct development costs for *Blue Streak* have totalled £65 million (plus the cost of the Spadeadam engine test beds and investment in the development of the Woomera Range in Australia), but expenditure required to complete the missile would be in the order of £500 to 600 million.

●

Britain's Minister of Aviation Duncan Sandys made a series of visits to European countries in April to discuss closer cooperation between national aircraft industries. First port of call was Paris (April 11th to 14th) for talks with the French Government and the major manufacturers, followed on April 21st by a trip to Germany. Main subjects discussed in both countries are reported to have been: 1) the development of a VTOL single-seat combat aircraft; 2) joint development by all three countries of a European long-haul supersonic airliner; and 3) development of an automatic blind landing system for all European airports, based on British studies and to be continued in association with France and Germany.

A Bonn statement issued after the preliminary talks said that West Germany had agreed to join with Britain and France in the development and production of military aircraft and missiles for NATO. British, French and German experts were expected to meet shortly to draw up plans for joint development of VTO aircraft and electronic equipment for European air defence.

Other points reportedly covered in the West German talks include: guided weapons and the use of *Blue Streak* as a satellite launcher; possible British participation in the European F-104 programme; and possible German procurement of the Blackburn NA.39 for the Navy.

●

The Textron Corporation, of Providence, Rhode Island, has announced plans to purchase the Bell Aircraft Corporation's defence and aircraft business and major plant properties, for a cash sum reported to be in excess of $30 million. Bell Aircraft Corporation's operating units have been reorganized into two self-contained groups. The Bell Defense Group comprises the Niagara Frontier Division at Buffalo, N.Y. (rocket engines, electronics, V/STOL aircraft, space systems and techniques), Bell Helicopter Corporation, of Fort Worth, Texas (military and commercial helicopters) and Hydraulic Research and Manufacturing Co., of Burbank, Calif. (electro-hydraulic servo systems and valves). The Bell Commercial group is not affected by the sale and will remain part of the Bell Aircraft Corporation.

On completion of the sale, on which stockholders are to vote in June, the Bell Defense Group will be reorganized as the *Bell Aerospace Corporation,* an autonomous wholly-owned subsidiary of Textron. Bell Aircraft's top management, headed by Chairman Leston Faneuf and President Harvey Gaylord, will move to the new corporation. The transaction is expected to add sales valued at $100 million a year to the Textron combine's 1959 sales figures of $308 million.

●

Ferranti Ltd. and Bendix Aviation Corporation have signed an agreement under which Bendix becomes sole United States distributor and service representative for the new Ferranti systems of machine tool control. Bendix will set up a computer centre in Detroit to supply magnetic tape for this equipment. The Ferranti system's transistorized electronic equipment reads blueprint information stored on punched tape and transmits it to electrically or hydraulically powered machine tools which shape the finished parts.

●

The Garrett Corporation has announced a licensing agreement under which Robert Bosch GmbH, of Stuttgart, is to manufacture and sell Garrett diesel accessories, including turbochargers and related control systems. Bosch may establish production manufacturing in the Federal German Republic and France (including Algeria and French African territories), and its sales area will cover all free world countries other than the United States, Canada, the United Kingdom and Eire. Rotol Ltd., of Gloucester, is the Garrett licensee for turbochargers in the U.K.

●

Interaero GmbH is the name of a new West German company formed jointly by Garrett International S.A., of Geneva, and German industrialist Hans Liebherr to manufacture Garrett-designed air conditioning and pressurization systems and electronic central air data systems for the Lockheed F-104G and Fiat G.91 licence production models. The new company is to construct a manufacturing plant at Lindenburg, in southern Germany.

●

France's Sud-Aviation and Marcel Dassault have announced signature of a cooperation agreement covering the *Communauté/Spirale/Voltigeur* family of aircraft and a supersonic airliner project. Dassault will be the prime contractor for the former in the event a production order is forthcoming, and the aircraft will be designated "Dassault-Sud." Dassault will also give Sud the benefit of technical experience gained with the Mach 2 *Mirage III* and *IV* for a future version of the *Caravelle* as a supersonic (Mach 2 or 2.2 transport; this aircraft will bear the designation "Sud-Dassault."

Commenting on the agreement, Georges Héreil of Sud-Aviation and Marcel Dassault have said that the terms cover the following points: 1) test and development of the Sud-Aviation SE.118 *Voltigeur* would be halted at the end of April; 2) the Sud-Aviation - Douglas agreement will also cover eventual export sales of the Dassault-Sud *Communauté*; 3) Sud and Dassault will participate equally in the development and design of the Sud-Dassault supersonic transport, but Sud will be wholly responsible (in association with Douglas) for handling sales. The agreement still has to be approved by the French Government.

●

Westinghouse Electric Corporation has received a $38.5 million U.S. Navy contract to design, develop and build the long-range radar for the new *Typhon* air defence missile system. The Navy says that *Typhon* will involve two distinct missiles, a long-range missile formerly known as the *Super Talos* and a medium-range missile formerly known as the *Super Tartar.* Both will employ the solid-propellant booster motor and the ramjet sustainer motor used in the *Talos* programme. The Typhon weapon control subsystem will consist of advanced long-range search, track and guidance radar, high-speed computers for almost instantaneous target selection, and display and monitoring equipment. Prime contractor for engineering and development of the overall weapons systems is the Applied Physics Laboratory of Johns Hopkins University.

●

The Martin Company is developing a fifth version of the *Bullpup* air-to-surface missile, under a $2,561,000 Navy contract. The Navy says that the new weapon, designated *Bullpup B,* will have "improved capabilities, but has not divulged further information.

U.S. Fleet units were equipped with the first version of the *Bullpup,* a solid-propellant weapon with a range of 3 miles, in April, 1959. Since then the Navy has announced that a second version, with a pre-packaged liquid-propellant engine, more powerful warhead and improved guidance was in production. A third *Bullpup,* designated GAM-83A, is currently in production for the USAF, and a fourth version, the GAM-83B, is under development (nuclear warhead and other improved features).

●

Howard Hughes has announced a $340 million financing programme to pay for the expanding jet transport fleet of Trans World Airlines, a subsidiary of Hughes Tool Company. Firstly, up to $190 million is to be sought through private placement with banks, insurance companies and other institutional lenders. Secondly, TWA plans to offer its stockholders $100 million of subordinated income debentures; Hughes Tool Co. will purchase not only its pro rata portion ($78 million) but also enough of any debentures not taken up by other shareholders to provide TWA with at least $100 million. Finally, TWA will provide the remaining $50 million as far as possible from its own resources, with Hughes making good any amount by which the carrier is short of the total.

When completed, the new financing programme will make it possible for TWA to own all its current and future jet aircraft. The carrier is at present leasing from Hughes Tool Co. 15 Boeing 707-131s and five 707-331s. A further seven 707-331s and a fleet of 30 Convair 880-22s are due to come into service this summer.

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* Interavia Air Letter is a daily international news digest published in English, French ("Courrier Aérien") and German ("Luft-Post"). All rights reserved.

BEA and BOAC are to work together with British United Airways (the company formed out of the recent merger between the air transport interests of Airwork Ltd. and Hunting-Clan Air Transport Ltd.), Eagle Airways and Skyways to provide services on many colonial routes with substantial fare cuts to come into effect next autumn. From October 1st economy fares up to 16 percent below existing tourist rates will be introduced on all cabotage routes, a new coach or third class rate on these routes between 25 and 30 percent below existing tourist fares (these fares will be available only to U.K. citizens or residents of British territories overseas and will be valid only for the whole journey between these territories and the U.K.), and new inclusive tour rates and off-peak student rates of approximately 40 to 50 percent below present tourist rates.

BEA will cooperate with Skyways on the London-Tunis-Malta route, and with British United Airways on the Gibraltar run, while BOAC's partners will be British United Airways, East African Airways and Central African Airways on cabotage routes to East and Central Africa, and Eagle Airways between Britain and Bermuda and the Bahamas.

●

Transports Aériens Intercontinentaux has now arranged financing for its two Douglas DC-8s, which will cost a total of $16.5 million. The French independent airline has secured an Export-Import Bank loan of $6 million, and Douglas will give a credit of $2 million. The Crédit Maritime et Fluvial has arranged a loan of 9 million Swiss francs (approximately $2 million), and a medium-term loan of 12.5 million new French francs will provide a further $2.5 million. The balance of $3.65 million will come from TAI's cash reserves and amortization fund. The company's capital is to be increased to meet the costs of the new aircraft and to achieve a better balance of capital against contractual liabilities.

●

Malev, the Hungarian national carrier, has signed an exclusive contract with Air BP to meet all its fuel and service requirements at west European airports. Malev is operating flights from Budapest to nine western countries and plans further extensions of this network to include, amongst other cities, London. Air BP has also been given a contract to supply all western carriers' aviation fuel requirements at Budapest.

●

United Air Lines' $65 million deal with Sud-Aviation for 20 *Caravelles* includes the trade-in of eight Douglas DC-6s and seven DC-7s, valued by UAL at approximately $6 million. SFERMA will reportedly carry out modifications and conversion to all-cargo configuration if and when required, and the aircraft will be offered for sale or lease to gain the best possible return. If after 12 months (i.e., February 1961) the aircraft have not been disposed of, they will be written down to scrap value, and any loss will be shared equally by UAL and Sud-Aviation. UAL has reportedly fixed a price of $480,000 each on the DC-6s, something like $130,000 more than other carriers are asking.

●

Air France and LOT representatives meeting in Warsaw have reached agreement on Warsaw-Paris services. Air France gets rights to operate a service either direct or via Prague and Berlin, with traffic rights between those cities and Warsaw, and to extend Warsaw services on to Moscow. LOT will operate Warsaw-Paris with intermediate stops at Berlin and Zurich and with traffic rights between these two points and Paris; LOT also gets rights to operate through Paris to another destination to be determined later.

Major-General Alfred Zerbel has been appointed Inspector of the West German Army, in succession to the late General Röttinger.

●

The NATO Standing Group in Washington has approved a plan for the establishment of a guided missile training centre in Crete. Costs are estimated at over $50 million and will be borne by NATO. The centre will be used for missiles with a range not exceeding 150 miles. Administration and operational control will be the responsibility of the Greek Government but the instructors will be both American and Greek. The facilities will be available to all NATO nations.

●

British European Airways announces a record profit of £2 million for the financial year ended March 31st, 1960, against the 1958-59 figure of £232,695. During 1959-60 BEA carried some 3,250,000 passengers and performed 1,100 million passenger-miles.

●

London Airport is to have a new long-haul terminal to replace the present "shanty town." The new facility, work on which has already begun, will be situated in the Central Area of the airport and will consist of a 430x280 ft passenger building flanked by two office blocks along a rectangular forecourt. The first half of the passenger building is expected to be ready by mid-1961, and the southern office block by the end of that year; the second half of the passenger building is scheduled for completion by early 1962, with the northern office block ready by June 1962. Work on the extension of London Airport's main runway (28L/10R) from 9,576 to 11,000 ft is scheduled to begin in May, 1960.

●

The U.S. Army has announced that it will hold a design competition later this year for a light observation helicopter to replace the Cessna L-19 fixed-wing aircraft and the Bell H-13 and Hiller H-23 helicopters. The new helicopter must be lighter and smaller than the H-13, but must have a cruising speed of at least 126 m.p.h., three hours' flight duration and a payload of at least 400 lb plus the pilot and three hours' fuel under hot weather and high altitude flying conditions. Powerplant will be a gas turbine engine. Two different designs will be selected for development, and flight testing in 1963 will lead to selection of the final design and a production contract. Production and procurement are expected to begin in 1964 or 1965.

●

Costruzioni Aeronautiche Giovanni Agusta has published supplementary details of its AZ-101G and A-104 helicopters. A prototype of the medium-weight AZ-101G, which is designed for troop transport (30 troops), the transport of vehicles or anti-submarine duties, has been ordered for the Italian Air Force. The model has a rear loading door, which can be left open during flight to accommodate bulky articles. A civil version is also planned. The prototype of the AZ-101G (fully equipped for instrument flying) will have three de Havilland Gnome (GE T58) shaft turbines of 1,050 s.h.p. take-off power each four-blade main and tail rotors and a fuel capacity of 440 Imperial gallons for a range of around 270 nautical miles.

A new model just announced is the two-seat Agusta A-104 helicopter, derived from the Agusta A-103. This is powered by a 140 h.p. M.V.A. 120 engine (derated to 120 h.p.). Main rotor diameter 26 ft, weight empty 840 lb, gross weight approximately 1,415 lb, maximum sea level speed roughly 87 knots, cruising 74 knots.

●

Dassault Mirage III fighters have logged a total of roughly 1,000 hours of test flying time since the first flight on May 12th, 1958. The complete series of airframe tests throughout the whole speed range has been finished, and weapons tests are now in progress. Flight testing with the full armament will begin in July.

●

The Dassault Spirale twin-engine overseas multi-purpose aircraft began flight tests at Bordeaux-Mérignac on April 8th, 1960. Power is supplied by Turboméca *Bastan* propeller turbines.

●

Production of the IL-14P twin-engine airliner has now ceased at East Germany's VEB Flugzeugwerke Dresden, the majority of the aircraft having been exported to Bulgaria, China, Poland, Rumania, Hungary and Vietnam. Users are, however, offered the possibility of conversion to a 32 or 36 passenger layout. The East German IL-14P is normally designed for 26 passengers. On the other hand, the 1,900 h.p., 14-cylinder ASh-82T-7 two-row radial engine which powers the IL-14P, is still in production at VEB Industriewerk Karl-Marx-Stadt. Present overhaul life is given as 700 hours, but is expected to be raised to 1,000 hours shortly.

●

Boeing, Convair and North American have submitted proposals ("Study Requirements 100") to the U.S. Air Force for a "third generation" of ballistic missiles. These would have ranges of the order of 9,500 miles.

●

"Hyperjet" is the name of a combined rocket/ramjet powerplant projected by Marquardt Corporation. This unit, which uses storable propellants including boron fuel, produced a thrust of 100,000 lb when it was ground tested at Edwards AFB recently. The company claims it could be boosted to 250,000 lb thrust with slight modifications. The ramjet portion has already been flight-tested in the Lockheed X-7 experimental vehicle, which flew at speeds of over 2,600 m.p.h. and has reached altitudes of 90,000 ft.

●

The International Air Transport Association is to hold the first world-wide meeting of airlines to consider expectations from the next generation of supersonic transport aircraft, some time in the spring of 1961. Manufacturers, air forces, research establishments and other international organizations will be invited to join the discussions. A special advisory group headed by Knut Hagrup, SAS Vice President and Chairman of the IATA Technical Committee, has been established to draft the agenda and terms of reference for the meeting, which will be the principal feature of the 1961 IATA Technical Conference scheduled for mid-May at an as yet undecided location in North America.

Photo credits: Front cover: Boeing Airplane; pp. 553-555: Howard Levy (1), manufacturers (1); pp. 556-560: Howard Levy (11), manufacturers (19); pp. 565-566: author; pp. 567-568: author (1), manufacturers (2); pp. 569-573: author; pp. 574-576: manufacturers; pp. 577-579: KLM (3), Schiphol Airport (5), Interavia files (3); p. 580: manufacturers; pp. 589-591: author; pp. 592-593: manufacturers; pp. 594-596: Howard Levy (3), manufacturers (6), Interavia files (2); pp. 601-602: manufacturers; pp. 602-603: author; pp. 604-605: manufacturers; pp. 606-608: author; p. 611: Kurt Flückiger, Zurich (2), Air France (1); pp. 613-614: NASA (3), manufacturers (2).

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PARIS	NEW YORK	6 HRS. 45 MIN.
NEW YORK	PARIS	5 HRS. 44 MIN.
NEW YORK	ROME	7 HRS. 48 MIN.
LONDON	ROME	2 HRS. 02 MIN.
NEW YORK	CARACAS	3 HRS. 56 MIN.
NEW YORK	FRANKFURT	6 HRS. 54 MIN.
CAIRO	ROME	2 HRS. 32 MIN.
SYDNEY	DARWIN	3 HRS. 57 MIN.
FRANKFURT	ROME	1 HR. 31 MIN.
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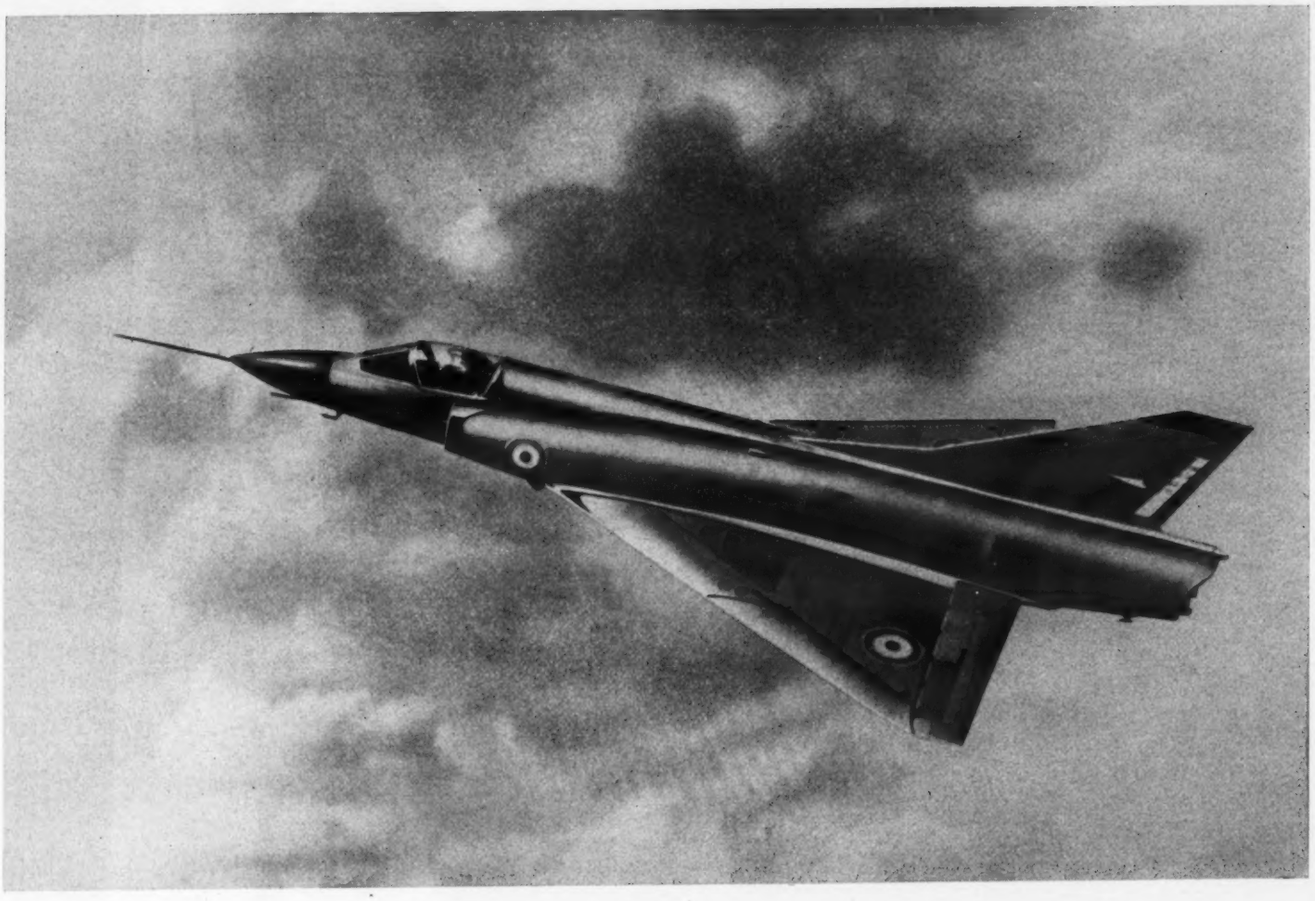

MIRAGE IV

Mach 2

LONG-RANGE BOMBER

Générale Aéronautique Marcel Dassault

FRANCE

23
23
23
1957 : 2600 m
1960 : 3900 m
GENEVA
is ready
for the jet aircraft age
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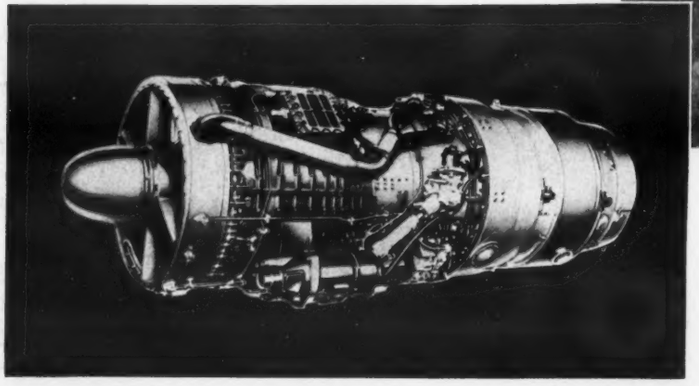

Avon turbo-jets of from 10,500 to 12,725 lb. thrust power all the 80 Sud Aviation Caravelles now in service with, or on order for, 10 airlines.

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U.S. Aviation Stocks, Capital, Dividends, Prices etc.

Profits, dividends and prices given in the following table betray the effects of the transition from quantity production of aircraft to development of missiles and the financial burdens imposed by getting jet airliners into production. Compared with the peak figures recorded in 1956, stocks of aircraft and engine manufacturing companies have dropped by up to 30 percent in price—and by nearly 50 percent in the case of two "favourites." Nevertheless the New York Stock Exchange looks forward to the remainder of 1960 with a modest degree of optimism. The electronic industry has remained untouched by this movement, and with few exceptions other equipment companies have also shown no signs of weakening.

The following changes compared with the previous year must be reported: Bendix Aviation Corporation (b) has changed its name to The Bendix Corporation; Sylvania Electric Products has been taken over by General Telephone and Electronics Corporation (f), the biggest independent telephone company (outside the Bell concern) in the United States, which had already been showing considerable interest in the electronics business; finally, Vertol Aircraft has become a division of Boeing Airplane (c).

Other notes in the table refer to the following: a = changes in capital (stock splits, stock dividends, etc.). In November 1959 American Machine & Foundry offered its shareholpers two new shares for every old share held; in February 1960 Firestone Tire & Rubber three new for one old; in December 1959 Goodyear Tire & Rubber three for one; in May 1959 International Business Machines three for two; in March 1959 International Telephone and Telegraph two for one; in January 1959 Lockheed two for one and in April 1959 Thiokol Chemical three for one.

d = deficit e = estimated st. = stock dividend

The figures in the "production" column denote:

① Aircraft and airframe accessories
② Helicopters
③ Missiles and accessories
④ Engines and accessories
⑤ Electrical and electronic equipment
⑥ Other airborne and ground equipment, plus plant equipment
⑦ Weapons, ammunition, explosives, fuels

Company	Production	No. of shares and par value	Dividends in $ 1958	Dividends in $ 1959	Prices 22.4.60	High 1959	Low 1959	Profit per share in $ 1958	Profit per share in $ 1959	Short-term liabilities in million $	Realizable assets in million $	Liquid assets in million $
Aircraft, Missiles and Equipment Industry												
American Bosch Arma	④⑤⑦	1 882 714 ($ 2)	1.20	1.20	21 1/8	39 3/8	23 3/4	2.50	1.83	34.6	53.3	5.61
American Machine & Foundry [a]	⑤③⑥	7 430 815 ($ 3.50)	1.70	1.07 1/2	62 1/2	52 3/8	26 3/4	1.66	2.52	64.6	135	17.0
Avco Corp.	③④	10 249 910 ($ 3)	0.40	0.40	13	17 5/8	10 1/2	1.01	0.93	45.2	137	22.4
Beech Aircraft	①	883 021 ($ 1)	1.60	1.60	74 1/2	65	28 1/2	4.03	4.74	18.2	42.0	7.10
Bell Aircraft	①②③	2 697 826 ($ 1)	0.80	0.50	13	24 3/8	13	1.77	1.26	34.2	58.8	7.96
Bendix Corp. [a,b]	③⑤⑥	5 106 731 ($ 5)	2.40	2.40	65	89	63	4.18	5.37	148	289	16.8
Boeing Airplane [c]	①③	7 466 406 ($ 5)	1.00	1.00	24 5/8	46 1/2	29 1/8	4.01	1.65	333	524	46.5
Burroughs Corp.	⑤⑥	6 621 498 ($ 5)	1.00	1.00	32 7/8	45 3/4	28 3/4	0.97	1.07	124	229	14.3
Cessna Aircraft [g]	①⑤	1 071 502 ($ 1)	1.45	0.63 1/3	39	34 5/8	14 5/8	1.87	2.47	14.4	38.5	3.66
Chance Vought Aircraft	①③	1 189 390 ($ 1)	2.00	2.00	27 3/4	42 1/2	25 5/8	7.55	4.12	45.4	81.5	17.8
Chrysler Corp.	③	8 750 113 ($ 25)	1.50	1.00	51 1/4	72 5/8	50 5/8	3.88 [d]	0.62 [d]	415	690	194
Collins Radio	⑤	1 959 497 ($ 1)	—	4 % st.	.	72 1/8	22	0.56	1.95	65.9	96.4	6.53
Curtiss-Wright	④	7 664 719 ($ 1)	2.50	2.25	20 7/8	40 3/4	27 1/8	3.11	1.71	48.0	175	62.9
Douglas Aircraft [h]	①③	3 816 860 (no)	2.50	1.00	29 3/4	59 3/4	37	4.41	8.86 [d]	233	387	35.2
Fairchild Engine & Airplane	①③	3 038 258 ($ 1)	—	—	7 1/2	10 1/2	7 1/4	1.96 [d]	0.41	51.7	57.7	7.50
Firestone Tire & Rubber Co. [a]	③⑥	26 382 096 (no)	.	0.86 2/3	36 1/4	50 3/8	40 1/4	2.08	2.45	153	547	69.5
Food Machinery & Chemical	③⑥⑦	6 914 532 ($ 10)	1.05	1.20	49	55 3/8	40	2.39	2.92	39.7	160	33.9
Ford Motor [a]	③⑤	16 465 279 ($ 5)	2.00	2.80	70 1/2	93 1/2	50 3/4	2.12	8.23	528	1358	666
Garrett	⑥	1 064 972 ($ 2)	2.00	2.20	46	50 7/8	38	3.98	4.61	57.0	92.3	8.10
General Dynamics	①③⑥	9 943 992 ($ 1)	2.00	2.00	41 1/8	66 1/2	42 7/8	3.95	.	268	556	85.5
General Electric	④⑤⑦	87 925 923 ($ 5)	2.00	2.00	89 3/4	99 7/8	74	2.77	3.17	739	1567	596
General Motors	④⑤⑥	281 697 653 ($ 1.66 2/3)	2.00	2.00	44 7/8	58 7/8	45	2.21	3.05	1139	3705	1263
General Precision Equipment	⑤⑥	1 126 625 ($ 1)	0.85	0.25	51 7/8	60	31 1/2	0.74 [d]	2.63	50.8	110	10.0
General Telephone & Electronics [f]	⑤	22 783 694 ($ 10)	2.00	2.10	84 3/8	85 1/8	60 1/8	2.93	3.24	249	456	89.5
General Tire & Rubber	③⑤⑥	5 276 670 ($ 0.83 1/3)	0.70	0.77 1/2	59 5/8	86 3/4	44 1/8	2.06	4.84	82.4	195	13.2
Goodyear Tire & Rubber [a]	⑥	33 159 756 (no)	2.40	0.82 1/2	38	51 1/4	39 1/8	2.03	2.29	121	632	46.8
Grumman Aircr. Engineering	①③	2 200 000 ($ 1)	1.12 1/2	1.50	26 1/2	30 3/4	20 1/2	1.13	2.24	40.2	71.8	7.46
International Business Machines [a]	⑤⑥	18 268 943 ($ 5)	2.60	2.03	458	488	329	6.93	7.97	122	538	315
Internat. Telephone & Telegraph [a]	⑤	15 412 598 (no)	0.90	0.97 1/2	41 1/4	45 1/2	27 7/8	1.81	1.85 [e]	221	455	56.8
Lear Inc.	③⑤⑥	. ($ 0.50)	0.10	0.40	15	23 1/4	9 1/8	0.68	0.91	31.8	44.0	3.10
Lockheed Aircraft [a]	①③	7 232 135 ($ 1)	1.20	1.20	22 1/8	39 3/4	24 5/8	2.75	1.21	328	404	36.9
Martin Co.	③	2 928 340 ($ 1)	1.60	1.60	38 3/4	62 3/4	32 3/8	4.01	4.34	79.6	121	10.8
McDonnell Aircraft [a]	①③	1 709 778 ($ 5)	1.00	1.00	36	49 3/4	29 3/4	6.33	6.10	.	.	.
Minneapolis Honeywell Regulator	④⑥	6 994 853 ($ 1.50)	1.75	1.85	148 3/4	150	111 1/2	3.23	4.20	55.1	204	21.6
North American Aviation	①③④	8 135 451 ($ 1)	1.60	1.60	31 1/8	52 5/8	30 1/4	3.34	3.78	175	310	48.8
Northrop Aircraft	①③⑤	1 826 010 ($ 1)	1.60	1.60	28 7/8	44 3/4	24 5/8	4.31	4.01	48.6	88.4	9.91
Olin Mathieson Chemical	⑦	13 324 589 ($ 5)	1.50	1.00	47	58 3/4	41 7/8	0.70	2.81	102	361	105
Philco Corp.	③⑤	4 074 866 ($ 3)	2 % st.	0.25	31 5/8	36 3/4	21	0.61	1.67	49.3	150	26.2
Piper Aircraft [a]	①	973 582 ($ 1)	1.00	1.00	59 1/4	53 3/4	20 1/4	2.36	3.00	5.56	13.7	0.80
Radio Corp. of America	⑤	14 271 378 (no)	1.50	1.50	74 1/4	73 1/4	43 1/8	2.01	2.59	220	536	58.4
Republic Aviation	①③	1 472 013 ($ 1)	2.00	1.00	22 3/4	28 3/4	17 1/8	3.48	2.37	49.9	82.7	14.2
Rohr Aircraft	①	1 853 884 ($ 1)	0.93	1.00	.	24 3/4	16	2.87	1.40	62.1	86.4	5.89
Sperry Rand	③⑤⑥	28 283 441 ($ 0.50)	0.80	0.80	21 1/8	28 1/4	21 1/8	0.96	1.40 [e]	212	509	53.0
Temco Aircraft	①③⑤	1 703 311 ($ 1)	0.75	0.70	.	19 3/8	10 1/2	1.50	0.68	11.6	28.0	4.27
Texas Instruments	⑤	3 914 730 ($ 1)	5 % st.	—	207 5/8	193 1/2	61 1/4	1.84	3.59	37.3	64.8	17.9
Thiokol Chemical [a]	④⑥⑦	4 546 447 ($ 1)	5 % st.	2 % st.	38 3/4	72	29 3/4	0.68	1.21	41.5	55.5	2.10
Thompson-Ramo-Wooldridge	③⑤	3 119 503 ($ 5)	1.40	1.40	57	70 1/4	52	2.86	3.02	80.4	148	15.2
United Aircraft	②④⑥	6 395 361 ($ 5)	3.00	2.50	33 3/8	66	36	6.41	4.26	236	397	36.7
Westinghouse Electric	④⑤⑥	34 679 456 ($ 6.25)	2.00	1.05	54 3/4	55 3/8	35 1/4	2.13	2.43	231	999	378
Air Transport Industry												
American Airlines		8 232 117 ($ 1)	1.00	1.00	18 5/8	33 3/8	23 1/8	1.94	2.53	79.7	115	65.4
Braniff Airways		2 948 119 ($ 2.50)	0.60	0.60	9 5/8	17 5/8	11 3/4	1.01	0.85	10.8	18.5	6.44
Capital Airlines		909 659 ($ 1)	—	—	8 7/8	23 7/8	12 3/4	0.23	1.93 [d]	15.9	21.8	6.33
Eastern Air Lines		3 108 604 ($ 1)	1.00	1.00	24 3/4	46 1/8	32	2.34	3.60 [e]	25.7	64.3	12.6
Flying Tiger Line		1 414 491 ($ 1)	5 % st.	—	.	20	10 5/8	0.40	0.71	5.85	8.26	3.46
KLM		1 429 190 (100 fl) *	1.85	1.85	29	39 3/8	27 1/8	2.30	.	29.7	52.9	25.5
National Airlines		1 745 015 ($ 1)	0.12 1/2	0.12 1/2	12 7/8	29 3/8	16 3/4	0.54 [d]	1.42	11.5	14.4	6.35
Northwest Airlines		1 383 501 ($ 10)	0.80	0.80	19	46 3/8	29 1/2	4.06	3.68	19.5	27.7	10.2
Pan American World Airways		6 580 198 ($ 1)	0.80	0.80	17 1/4	35 1/4	20 3/8	0.78	1.15 [e]	81.6	125	46.8
Seaboard & Western		. ($ 1)	—	—	6 7/8	14 3/4	6 7/8	0.30 [d]	.	6.53	6.06	3.47
Trans World Airlines		6 674 155 ($ 5)	—	—	13	24 5/8	16 5/8	0.26 [d]	1.50 [e]	88.2	113	22.9
United Air Lines		3 946 070 ($ 10)	0.50	0.50+ st.	27 3/4	45	30 7/8	3.88	3.50	77.5	87.7	31.3

* 100 fl = $ 26.50

INTERNATIONAL MEETINGS AND CONFERENCES

May 11th-14th : American Helicopter Society, Annual National Forum, Miami Beach, Fla.

May 18th : IATA Financial Committee, 19th Meeting, Venice, Italy.

May 22nd-26th : Airport Operator Council Annual Meeting, Columbus, Ohio.

May 23rd-24th : Annual Meeting of Arbeitsgemeinschaft Deutscher Verkehrsflughäfen, Bremen.

May 23rd-25th : Telemetering Conference (IAS, AIEE, ARS and ISA), Santa Monica, Calif.

May 23rd-28th : International Instruments, Electronics and Automation Exhibition, London.

May 24th-25th : Canadian Aeronautical Institute, Annual General Meeting, Chateau Laurier, Ottawa.

May 24th-28th : Japanese Rocket Society, 2nd International Symposium on Rockets and Astronautics, Tokyo.

May 26th-27th : IAS Specialists Meeting on Guidance of Aerospace Vehicles, Boston, Mass.

May 26th-June 5th : 12th International Trade Fair, Luxemburg.

May 28th-June 6th : British Gliding Association, 1st National Gliding Week.

May 30th-June 4th : Société Française d'Astronautique, Conference, Paris.

June 4th-19th : Eighth World Gliding Championships, Cologne-Butzweilerhof, Germany.

June 5th-9th : ASME Semi-Annual Meeting and Aviation Conference, Dallas, Tex.

June 7th : IATA Executive Committee, 47th Meeting, Noordwijk, Holland.

June 14th : IATA Coordination of Winter Timetables 1960/61, Dublin, Eire.

June 14th-16th : 35th Annual Meeting of the Aviation Distributors' and Manufacturers' Association, Montreal, Quebec.

June 15th-29th : 7th International Congress on Electronics and Nucleonics, Rome, Italy.

June 20th-23rd : AGARD Avionics Panel, 5th Ionospheric Research Committee Meeting, on Radio Wave Absorption, Athens, Greece.

June 28th-July 1st : IAS Summer Meeting, Los Angeles, Calif.

July 8th-9th : British Lockheed Trophy, Baginton, Coventry.

July 8th-10th : Aero Club of Italy Rally.

July 24th-Aug. 1st : British Gliding Association, 2nd National Gliding Week.

July 31st-Aug. 7th : World Parachuting Championships, Aero Club of Bulgaria, Sofia.

Aug. 11th : Aircraft Nuclear Propulsion and Small Reactors Information Meeting, Oak Ridge, Tenn.

Aug. 15th-20th : 11th International Astronautical Congress, Stockholm, Sweden.

Aug. 28th-Sep. 4th : FAI World Aerobatics Championships, Czechoslovak Aero Club.

Aug. 31st-Sep. 7th : 10th International Congress of Applied Mechanics, Stresa, Italy.

Sep. 5th-11th : SBAC Display and Exhibition, Farnborough.

Sep. 6th-24th : ICAO, Legal Committee, Montreal, Quebec.

Sep. 8th : IATA Executive Committee, 48th Meeting, Stockholm, Sweden.

Sep. 12th-16th : IATA 16th Annual General Meeting, Copenhagen, Denmark.

Sep. 12th-17th : 2nd International Congress of the Aeronautical Sciences, Zurich, Switzerland.

Dr. Berchtold on Protectionism in Air Transport

In Western Europe a certain atmosphere of nervous tension has made itself felt since the creation of the two rival trade zones, the Common Market and the Free Trade Area. And, in the view of some critics, European air transport seems to be in danger of "growing apart" in the same way as the Six and Seven countries. In his speech to the Swissair annual general meeting early in April, Managing Director Dr. Walter Berchtold specifically warned against the formation of "blocs" in European air transport, with particular reference to the Air Union consortium formed by Air France, Alitalia, Deutsche Lufthansa and Sabena.

Basically, the efforts being made by a number of airlines towards closer cooperation are an understandable reaction to the policy of "going it alone" which has been the vogue for the past decade and a half.

At the 1944 Chicago civil aviation conference several States made serious attempts to preserve post-war air transport from nationalistic separatism. Using the freedom of the seas as an example, they hoped to be able to arrive at a full-scale freedom of the air. But these hopes proved unfounded. The multilateral transport agreement, which was to have guaranteed commercial freedom for world air transport, remained on paper. Instead, as time went on an unconscionable number of bilateral air transport agreements were concluded, in which individual States bargained with one another for routes, landing rights and capacities for their airlines.

In more recent years, however, there has been a growing realization of the fact that the European area is too small, and the economic potential of the individual countries and their airlines too limited to permit all the companies concerned to maintain complete independence for ever. As general agreement on Government level was not immediately to be hoped for, the airlines were repeatedly advised from all sides to strive for closer cooperation among themselves in technical and commercial matters. With the transition to jet transports and the heavy demands which these aircraft made on airline finances, the call for such grouping of interests became increasingly loud.

Several carriers have already drawn their consequences from this situation.

In the autumn of 1958 Swissair and SAS signed an agreement to "share technical and operational tasks." They agreed on a joint technical basis for their jet fleet and split the maintenance work between them.[1]

The four Common Market airlines mentioned above went a step further. The Air Union organization projected by Air France, Alitalia, Deutsche Lufthansa and Sabena, which is due to come into operation in the autumn of 1960, is aimed at much closer commercial cooperation : the sharing of the four carriers' total international traffic on a quota basis and the distribution of revenues on a similar scale.

This is the form of cooperation which Dr. Berchtold fears will place heavy economic fetters on European air transport. In the portion of his speech devoted to Air Union he said:

"Air Union's objective is to concentrate the entire transport potential of the European carriers under a unified control. Although so far only the European Common Market nations' carriers have joined Air Union (with the exception of KLM), it still aims at central control for the development of the whole European air traffic volume. The future development of member companies is to be determined by a quota of the planned total traffic, and can no longer be influenced by successful management of the individual company. This concept of controlled economy is so far opposed to the basic views of Swissair, who believes that quality is the prerequisite for success and that success is a stimulus to improved quality and hence to the development of a company, that we were obliged to decide against joining Air Union. If it is true that Air Union is not directed against anybody and has no aggressive objectives apart from normal commercial competition, then there is no reason why there should not be friendly cooperation between Swissair and SAS on the one hand, and Air Union and its member companies on the other. Swissair is ready to cooperate at any time.

"However, there are certain signs that Air Union may be pursuing political aims which could lead to a new type of air transport imperialism within Europe. It has been said that the Transport Ministers of the countries concerned have agreed among themselves to grant only minimum traffic rights to carriers outside Air Union; however, one can probably assume that at any rate reciprocal traffic between neighbour countries will not be affected. In addition, it has recently become clear that Air Union has begun to ally itself with major non-European airlines. For example, Air France has recently reached a comprehensive pool agreement with Japan Air Lines, in which Air Union as such can scarcely be unconcerned. In other overseas areas, too, there is evidence of virulent activity by Air Union under the leadership of Air France. There can be no hiding the fact that protectionism in air transport policies is on the march."

[1]) At the end of April it was reported from Amsterdam that KLM had been having exploratory talks with a possible view to joining the Swissair-SAS group.

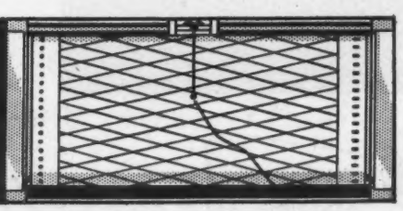
working pilot

The IFALPA delegate speaking to the ICAO Special Meeting, Montreal, February 1959

I should like to describe what we have been able to do using Radar for departures. Four aircraft taxi out at the same time. They are fully loaded, it is a hot night so they have an immediate problem. After take-off Departure Control wants immediate contact so we give them a call. Number 2 aircraft takes off two minutes later, and receives the same clearance until he picks up Radar Departure, who say " Turn left heading 050° "— now this is into inbound traffic, which means he will require continuous attention from Control to make sure he picks his way safely through the incoming traffic. Aircraft number 3, two minutes later, same as before, except when he picks up Radar Control, the Controller says " hold 4,000 ft. heading 130°," (he has vectored him off so as to clear the way for aircraft number 4). Aircraft number 4 receives the same departure, but he is told to hold 3,000 ft., and the Radar Controller's attention will also be especially directed towards him because he is bucking the flow of traffic in a place where he does not properly belong.

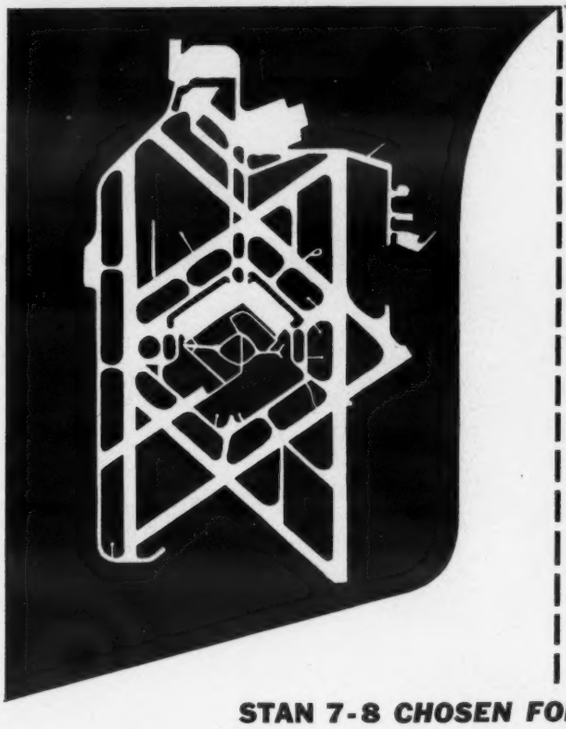
With regard to the overall achievement, we have now vectored four aircraft into a single airway. Only one of them has achieved the altitude he wanted, and unfortunately he will have to come down through the altitude of the others. Radar is a marvellous device, and it has solved many of our problems, but it is *not* a navigational aid. An area coverage system would not solve every problem, but it would provide the capability of outbound tracks that would take us immediately out of the area from whence discrete tracks could be drawn giving lateral separation of a safe order. This is a problem which is incidental to the use of single track airways, and we feel **it can be solved by lateral separation which should be made available through pictorial presentation coupled with area coverage.**

THE DECCA NAVIGATOR



THE NAVIGATION SYSTEM FOR THE JET AGE

THE DECCA NAVIGATOR COMPANY LIMITED LONDON



STC

HIGH ACCURACY

INSTRUMENT

LANDING SYSTEM

STAN 7-8 *CHOSEN FOR LONDON AIRPORT*

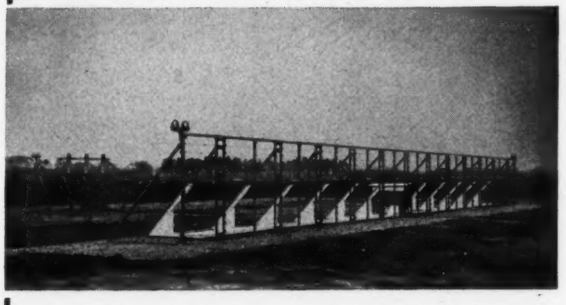
Dual STAN 7-8 High Accuracy Instrument Landing System specified for installation at London Airport. This equipment, which has automatic cut-over facilities, has been designed to provide an improved performance by use of a dual beam Localiser (STAN 7) in order to reduce substantially the effects of site imperfections.

The required 90 and 150 c/s modulations are derived from double sideband mechanical modulators whose input impedance is substantially constant and provide signals free from phase modulation.

The equipment is extensively transistorised and one Dual Localiser with one Dual Glide Path equipment contains only 28 valves (14 working).

STAN 7 LOCALISER EQUIPMENT
STAN 8 GLIDE PATH EQUIPMENT

Dual Beam Localiser reduces the effects of site errors
Freedom from false courses
360° omni-directional information
Reliable fail-safe monitoring fully transistorised
Independent setting-up controls
Improved servicing and fault location facilities
Mains supply, single-phase 100-120V or 200-250V 45-65c/s



The STAN 7-8 is in quantity production for the Ministry of Aviation and the STAN 7-8-9 which includes the marker has been specified by Radio Suisse for Zurich Airport and by the Régie des Vois Aériennes for Brussels Airport.

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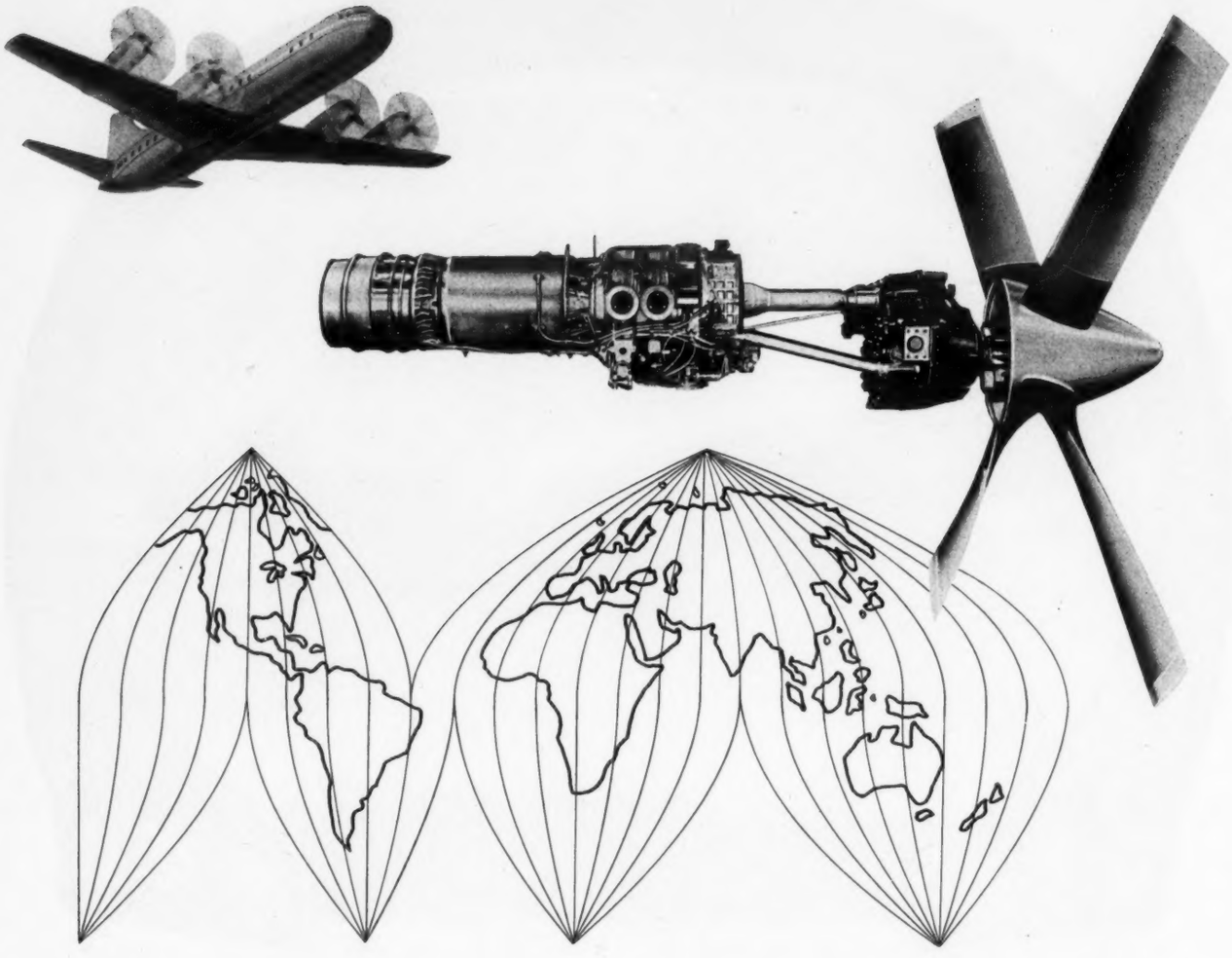

Here's modern Jet-age power

for 75 % of the world's needs!

This matched power team consisting of the Allison Model 501 Prop-jet Engines and Aeroproducts Turbo-propellers is delivering top performance and economy to 15 of the world's airlines. Allison-powered Lockheed Electras and C-130 military transports are acquiring flight experience at a rate exceeding 125,000 hours per month. Enthusiastic public acceptance is reflected in continuing high load factors.

This Allison power package is the workhorse of the jet age. The 501's power-to-weight ratio is 2.1 h.p. per pound —best of today's prop-jets. This design advantage, combined with efficient use of low-cost fuel, extends flight range, permits greater aircraft utilization and lowers operating cost to operators everywhere.

The immediate power response of the Allison 501 Engine permits shorter take-offs and landings . . . instantly provides adequate power for any requirement. The reverse thrust of the Aeroproducts Turbo-propellers provides braking action for positive stops—even under extreme weather conditions—performance ideally suited to operators serving smaller airports under a variety of weather conditions.

Allison-powered Lockheed C-130

Allison-powered Lockheed Electra

Allison-powered Convair 340

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Perfect vision is practically total blindness compared to NASARR . . . the lightweight, compact, all-weather radar system designed by Autonetics, a Division of North American Aviation, Inc. NASARR, the only multi-purpose radar system in production in the free world, has been selected to extend the capabilities of Germany's combat version of the Lockheed F-104G, being built for the German Air Force. NASARR has already been proved in service with the United States Air Force.

Autonetics is one of the world's leading producers of electronic devices for military and industrial use—with more than 14 years' successful experience in armament controls, inertial navigation, and data processing. Its products range from the inertial autonavigation system that guided the *USS Nautilus* under the polar ice to an advanced low-cost general-purpose digital computer for industrial and scientific use.

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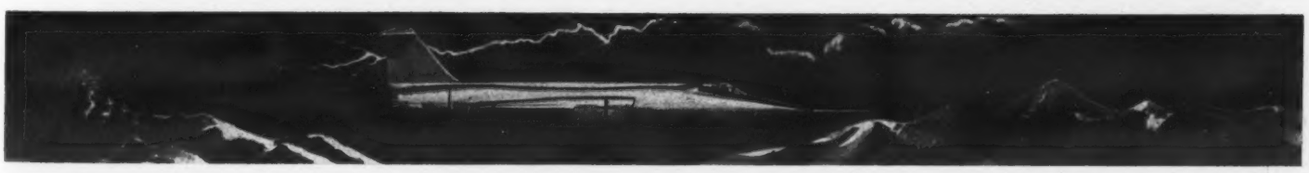
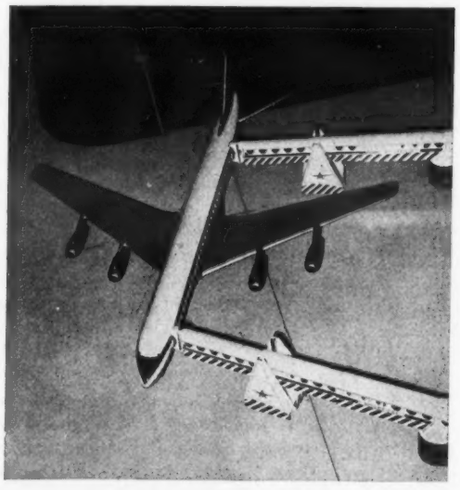
INERTIAL NAVIGATION / ARMAMENT AND FLIGHT CONTROL / COMPUTERS AND DATA SYSTEMS



AIRCRAFT OVERHAUL AND IRAN *Fixed wing aircraft:* Neptune P2-V-5, Martin " Mariner ", Lockheed T33 " Shooting Star ", F86K North American " Sabres ", Canadian de Havilland " Beavers ", Grumman " Avengers " TBM-3S2 and TBW-3W2, L-19 Cessna, Beech "Super 18 Beechcraft". *Helicopters:* Sikorsky S55, H-19 and H-34, Hiller H-23, Bell H-13.
DEVELOPMENT AND PRODUCTION: H-3 " Kolibrie " helicopter, " Aviobridge " hydraulically operated telescopic passenger gangway.
DEVELOPMENT: AT-21 pulsejet powered pilotless target- and photo-reconnaissance drone.
CONVERSION AND OVERHAUL: Douglas DC-6 aircraft.
LICENCE PRODUCTION: Lockheed F 104G "Starfighter".
CONTRACTORS TO: Royal Netherlands Navy, Royal Netherlands Air Force, U.S. Army Ordnance Industrial Center Europe, K.L.M. Royal Netherlands Airlines and various other civil airlines, Argentine Navy etc.

Quality Control Department approved by: • *Netherlands Department of Civil Aviation (R.L.D.) under No. 6* • *Royal Netherlands Air Force* • *Royal Netherlands Navy* • *United States Army Ordnance Industrial Center Europe.*



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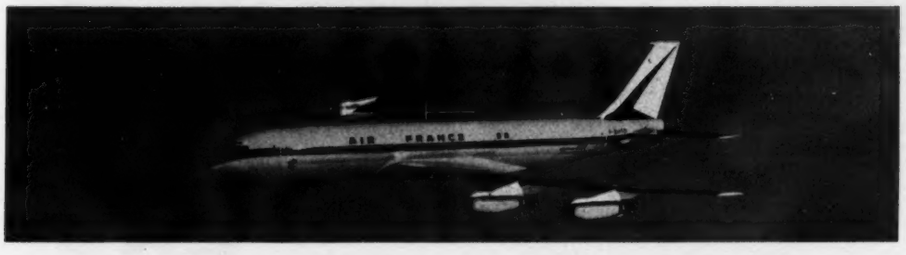

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Whether it's at one end, as in the quietly efficient Westland Wessex... whether it's at both ends, as in the outstanding Bristol 192... whether it's upright, horizontal or in any position in between, the Napier Gazelle free turbine engine will always satisfy the exacting demands of helicopter operation. Designed specifically for helicopter application, the Napier Gazelle, with its " any angle " installation, relieves the designer of many accepted limitations and gives him more opportunity to make proper use of fuselage space. The Napier Gazelle 1,650 s.h.p. free turbine was the first gas turbine engine in the world to receive Ministry of Supply 150-hour Helicopter Type Approval.

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Only the VANGUARD

paces pure jets at turbo-prop cost on short and medium haul routes

London-Hamburg
470 miles in 1 hour 13 minutes at 386 m.p.h. (a route record), tailwind 17 m.p.h.

Hamburg-London
1 hour 21 minutes (including a G.C.A. approach), headwind 25 m.p.h.

London-Brussels
230 miles in 45 minutes at 309 m.p.h., headwind 5 m.p.h.

Brussels-London
45 minutes, wind zero

London-Rome
955 miles in 2 hours 27 minutes at 386 m.p.h. at I.S.A. + 5°C. Wind zero (3 minutes faster than current pure jet schedule).

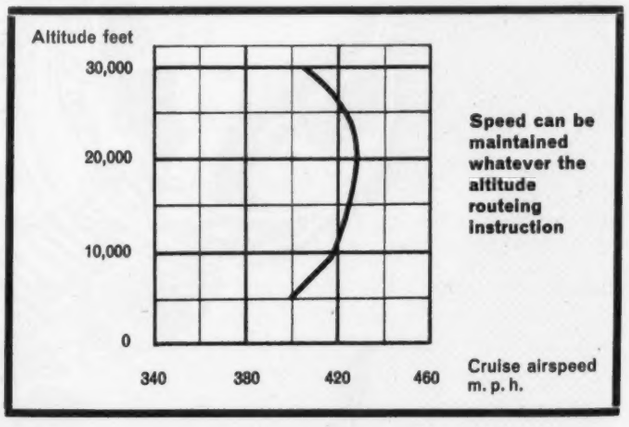
Rome-London
2 hours 35 minutes (including 10 minutes in the stack), headwind 12 m.p.h.

London-Paris
224 miles in 41 minutes. Winds light to zero.

Paris-London
54 minutes (A.T.C. delays), headwind 5 m.p.h.

PROOF of Vickers' claim that the VANGUARD would achieve pure-jet block times on short and short/medium routes has now been firmly established.
The times given in the table for stages up to 955 miles were achieved on commercial routes under actual route operating conditions. On the London-Rome flight the VANGUARD's time was *3 minutes less than the current four-engined pure jet schedule.*

Jet-competitive speed comes from the VANGUARD's ability to utilise a realistic and genuine cruise speed of over 400 m.p.h. at all altitudes between 5,000 ft and 30,000 ft. This is clearly shown on the cruise performance chart. A further result of this speed/height flexibility is a very low cost differential between routeings at widely differing altitudes. On a 500-mile trip, for instance, the difference between routeing at 10,000 ft and 20,000 ft (the most economical) is only $44. On the Rome-London flight the ten minutes' stacking over Epsom—due to heavy traffic—would have cost $70 with a pure jet. With the VANGUARD which stacked low, the cost was only $40.
On short and medium haul only an exceptionally fast jet could beat VANGUARD block times. No jet can compare with its remarkable operating economics. No jet can compare with its cheap-fare potential.



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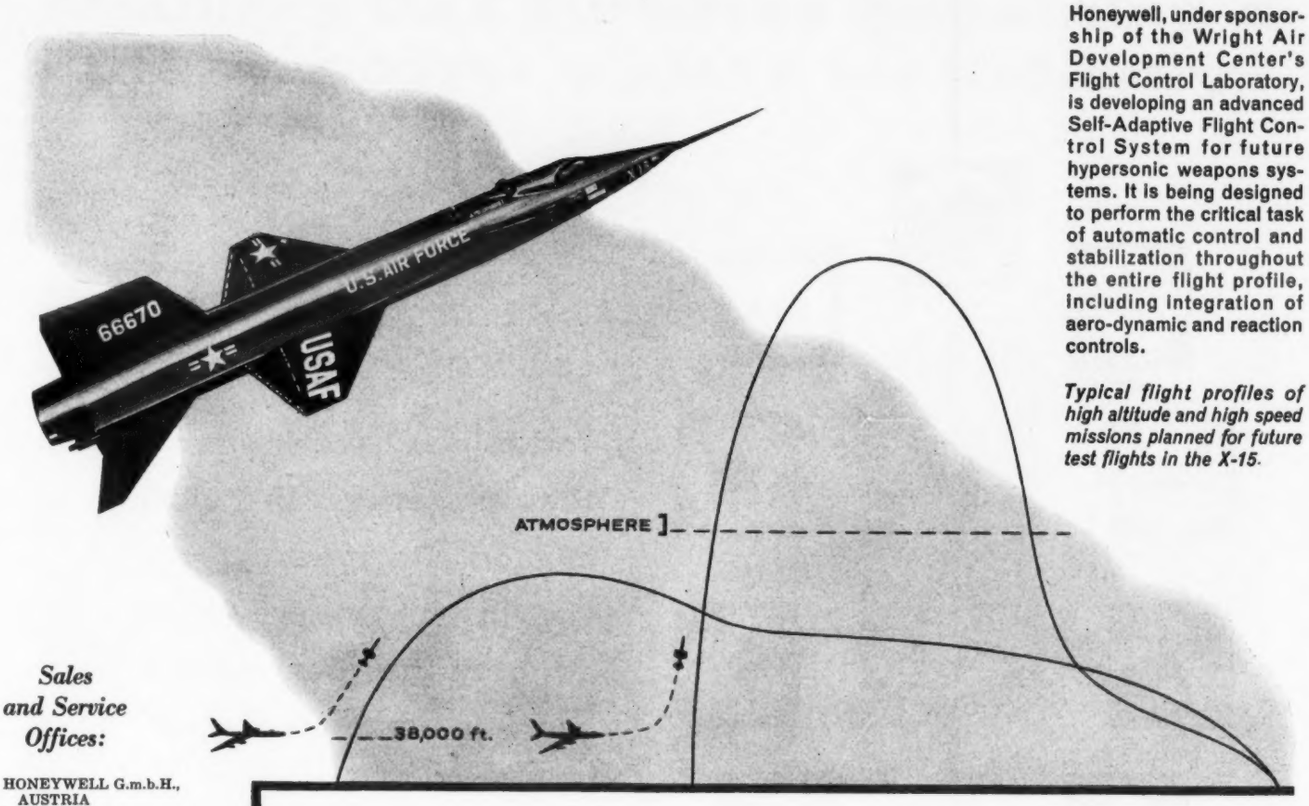

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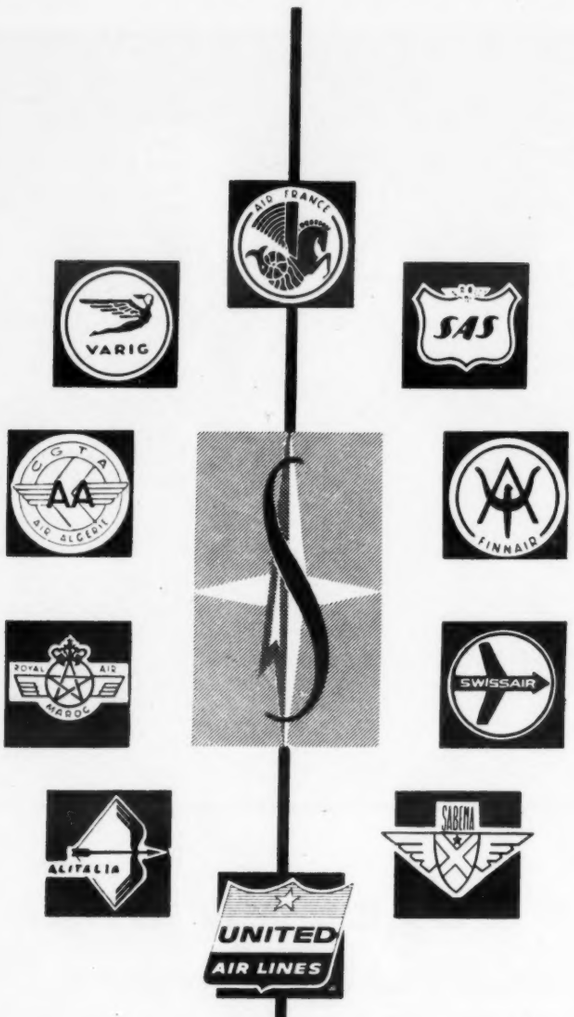

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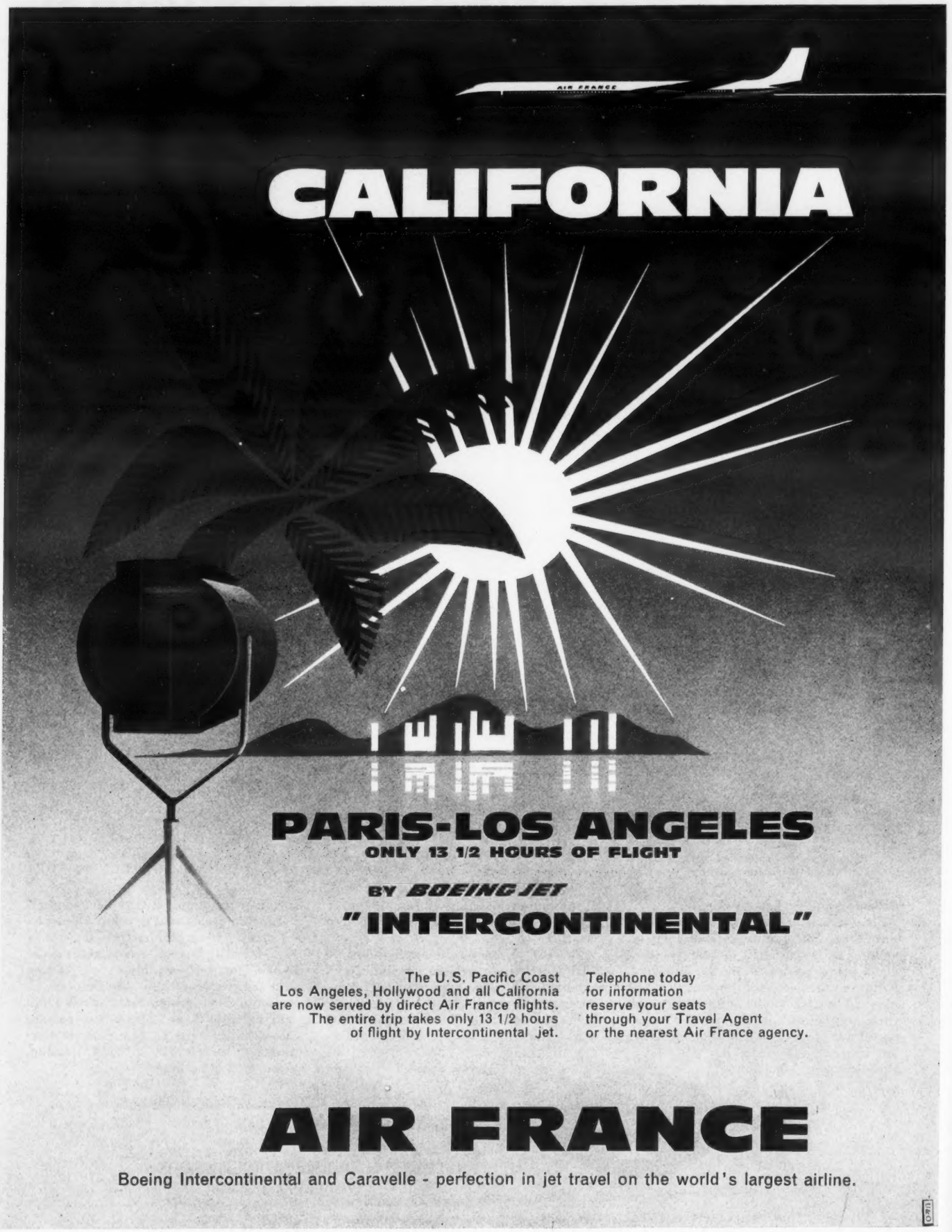
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Long Runways — For How Long?

The visions of flight of the pre-technical era always included weightless vertical take-off as a matter of course, and interestingly enough the same idea cropped up again much later in the many phantasies surrounding the subject of flying saucers.

Even the real live fabric flying machines of the pioneering days went a considerable way towards meeting this ideal, since they managed with astonishingly short take-off distances. But continuing technical development and the constant increase in speeds brought about an unhappy change. The dream of effortless rising and falling became the nightmare of miles of concrete runways.

The experts responsible for planning the ground organization, who for too long have been powerless to arrest this disquieting growth in runways, have naturally welcomed any technical innovation which promised relief: before World War II it was the rotary-wing aircraft, during recent years the vertical take-off fixed-wing aircraft, the difficulties of which were perhaps underestimated in the first flush of enthusiasm. When ICAO, for example, issued its critical report early in 1958 on deficiencies in preparations for the jet age, drawing attention to the shortage of 12,000 ft runways, the consoling thought was uttered that vertical take-off would in future remove many of the present difficulties. On the military side there were also certain NATO circles which enthusiastically endorsed this view.

In the meantime, however, demands have become more modest; there is no longer the same insistence on pure VTOL, and it has been recognized that STOL vehicles can also perform valuable services. Moreover, it has also been realized that concrete or metal cannot be dispensed with entirely.

This month's issue is devoted largely to the problems of short and vertical take-off, presented without illusions. Interavia *is not given to blind enthusiasms, but well knows from aviation history that today's daring designs can often become tomorrow's standard equipment.*

V/STOL is the Order of the Day

By General L. M. Chassin, Paris

The military authorities are always accused of being "one war behind." And when, by chance, they indulge in imaginative forecasts, they are called "crystal-gazers"; even the Air Force is told to keep its feet on the ground and its head out of the clouds! Hence the difficulty of the planner's situation. For despite the most skilled arguments to the contrary, everyone feels that war may one day break out again, and when it does, the materiel must be on hand to wage it under the best possible conditions with good chances of winning. For the military authorities, therefore, it is largely a matter of imagining the conditions under which future conflicts will take place and preparing the arsenals which they consider adequate.

At the present time, for instance, all observers agree on the "extreme unlikelihood" of an all-out atomic war which would bring our mechanized civilization face to face with suicide. But they do not disregard the possibility of an "accident," caused by the error or folly of a leader or subordinate.

It is also agreed that a limited nuclear war using tactical atomic weapons is virtually impossible, for the process of "going one better" would soon lead us to the original problem, that of all-out war.

There remains conventional warfare. But from the moment when the side which is the weaker in conventional resources firmly declares its intention of transforming any clash into a major nuclear conflict—which it is always capable of doing—this type of warfare, too, seems destined to be struck off the list of possibilities.

It may, however, be in the interests of certain nations, particularly those with a claim to world-wide importance, to be able to intervene rapidly at any point on the globe with a powerful combined force, either in response to the appeal of an ally, or to prevent an enemy from gaining hold of a vital strategic position. The primary requirement for such a force would be full mobility, in other words the maximum independence of such ground organization as it may find in the country in which it is operating. For a long time, the concept of such a force was based on the use of aircraft carriers, cruising off the coast and capable of both acting as a base for aircraft and landing troops on the shore. But the speed of an aircraft carrier is of necessity very low; hence, if rapid intervention is required in a remote corner of the world, a solution must be sought purely in the air.

Here we are not talking of space warfare, though this may indeed be possible tomorrow. For things happen quickly, and technical progress has always held strategy and tactics in a tyrannical grip.

This leaves us with subversive warfare, which since 1945 has been raging in Asia and Africa—and what are its prospects for tomorrow? But though Powers such as France and Great Britain are studying methods of dealing with this revolutionary form of combat, the USA and the USSR, preoccupied with cares of a higher nature, do not yet appear to have made the attempt to create the necessary counter-weapons—and perhaps they are wrong.

This picture might give us the impression that the risk of war is no longer imminent, in the near future at any rate, and might therefore tempt us to disarm. But military thinkers, call them prudent or retrograde, still instinctively feel that a world without war is too good to be true—in any case, such a world has never existed. Furthermore, by one of those right-about turns which are commonplace in the history of armament, the West has seen the re-emergence, after a ten-year eclipse, of a number of partisans of conventional warfare, whose arguments can be summarized as follows: since a nuclear war is unthinkable, and certain differences can, alas, be settled only by war, the sole solution lies in conventional warfare. Nor should the certainty of losing lead us to transform it into all-out nuclear war. Consequently, we should take advantage of the fact that the USSR is reducing her conventional forces to in-

crease our own, thus achieving, if not parity, a degree of balance enabling us to make it clear to the enemy that aggression is not a paying proposition.

Such a concept, which the writer has himself upheld in the past, would lead us back to the "big battalions" which we have so long sought to avoid, obliging us to increase the number of our divisions, ships and aircraft wings.

For this reason the military authorities who, after all, do not have unlimited funds at their disposal, are trying to find the answer to technical problems whose solutions can be applied to future conflicts of all kinds, whether probable or not. This, indeed, is true wisdom.

*

It must therefore be assumed that war of any kind could break out; we in the Air Force must have a clear idea of the role which we shall be called upon to play, both in a purely aerial conflict and in surface warfare. Finally, and this is the theme to which we return time and time again, there is the problem of building suitable aircraft. Although most observers agree that the aircraft will in future be replaced by the missile for the majority of missions, in particular air defence and strategic attack, even though, in surface combat, the newcomer may claim a role of ever-increasing importance on the battlefield, the fact nevertheless remains that:

a) in the immediate future, missiles will be neither numerous nor advanced enough to completely replace aircraft, even in fields in which they are undeniably superior;

b) even in a more distant future, the aircraft will be needed to perform all missions in which the human brain cannot be replaced by the most efficient robot.

It is thus clear that aircraft will continue to be built for a long time to come, but—and this is of prime importance to our argument—they will have to operate under increasingly difficult conditions with, hanging above them, the new sword of Damocles, the threat of nuclear bombardments so terrible in their destructive force that neither remoteness nor protection, nor even dispersal can suffice for their defence. The only reasonable solution is complete independence of ground facilities, in other words total mobility, enabling aircraft to operate without the handicap of the enormous air bases of today, which are doomed, in the words of the Russian Marshal Zhigarev, to become "gigantic holocausts." Hence the passionate interest which military planners all over the world are showing in VTOL and STOL aircraft.

The Army

The ground forces find themselves in a position where they must equip themselves for a war in which the belligerents would use nuclear weapons. They must therefore think in terms of a battlefield extending over several hundred miles in depth, bristling with atomic weapons which can cause heavy damage and suddenly contaminate huge areas if the wind is at all favourable. In such a situation, the army must be able both to disperse rapidly for defensive purposes and to concentrate rapidly so as to take the offensive, without being ineffectual in the former case or excessively vulnerable in the latter. On such a battlefield the functions of army aviation remain the classical functions of liaison, evacuation, observation and short-range transport; on the other hand, reconnaissance and support missions (close or long-range) as well as heavy transport, will remain the responsibility of the air force—at any rate for the time being. For some years past the army has realized that it would be extremely difficult to sustain air bases under the conditions reigning on an atomic battlefield. This is why it has been the first of the armed services, particularly in the United States, to devote considerable sums of money to the development of machines capable of operating without ground organization. Since helicopters are vulnerable, costly and organically limited in speed, the VTOL formula appeared to all to be the answer. It is true that there are still many technical problems to be overcome, but a number of promising experimental designs have already been built, such as the Doak X-16 and the Short SC.1. The engineers are on the track, and there can be no doubt that a satisfactory solution will be found within a few years. In the meantime, we shall have to content ourselves with STOL aircraft—provided they are true STOL models, i.e., they can use any kind of field as during the 1914–1918 war.

An army observation aircraft has no need of high speeds; on the contrary. The U.S. Army already has the Grumman AO-1 *Mohawk* conventional monoplane with two 1,000 h.p. turboprops, which has a speed range of from 40 to 275 knots. This light aircraft, which weighs only 7,770 lb empty, thus has a power/weight ratio as high as that of a fighter and achieves STOL performance without special devices. Moreover, it has an endurance of several hours, a most valuable attribute. Suitably armed, this model could probably serve as the light strike aircraft for subversive wars, which writers have been demanding since 1952.

For effective observation and ground attack missions, it is essential to be able to see; but if the ground is covered at too high a speed it is impossible to see properly, no matter what one does. In Algeria, fighter pilots admit that it sometimes takes them a full hour of sustained observation to detect details which a helicopter perceives immediately. On the other hand, low speeds entail vulnerability. And vulnerability, already dangerous in a theatre of subversive operations, would become unacceptable on a European battlefield.

Nevertheless, a STOL (or better still VTOL) observation aircraft would render the army inestimable services in all the types of war it might be called upon to wage, and it is easy to understand why the experts are demanding such an aircraft so urgently. In this case, incidentally, the question of logistics is of limited importance, since a lightweight VTOL observation aircraft could operate from any unprepared field close to the command post, without requiring a highly organized base.

Moreover, the army is also demanding lightweight transports for short ranges, which would complete the system and could, if necessary, bring up the supplies, spares and men required for the battlefield aircraft.

The Air Force

The various missions of the air force are well known: they consist of air defence, reconnaissance, strategic attack, transport, and also cooperation with the surface forces.

In all these missions, and no matter what the type of warfare envisaged, an exceedingly complex and increasingly vulnerable ground organization has been necessary. It is fully appreciated that such a situation cannot continue. In the event of an atomic war (and it is always necessary to foresee the worst) the NATO-type bases which were satisfactory as long as the West held the monopoly of nuclear power would be rapidly destroyed. Here, therefore, and even more so than in the case of the ground forces, we can appreciate the interest displayed by the world's air forces in the V/STOL formula. This would enable them to break free of the stranglehold of steadily increasing base sizes.

The technical problem to overcome is to enable the aircraft to land or take off almost vertically, while at the same time maintaining its performance in terms of speed and radius of action. It is necessary to examine this more closely.

In the piloted fighter aircraft, as far as it will remain for several years to come, the highest possible speed is absolutely essential if we wish to be able to destroy the supersonic bomber. But, in planning, it is essential to consider the optimum capabilities of the adversary. The North American air defence, for example, must depend on the piloted supersonic fighter as long as it cannot be equipped with surface-to-air missiles in sufficient numbers. The problem is even more acute for Europe. Consequently, we have seen the appearance of projects for Mach 2 VTOL fighters throughout almost the whole world.

It is not the intention to discuss the technical side of the problem here. But we can ask ourselves whether, when the VTOL fighter is actually in existence, it will still have any adversaries to engage. At all events there is still the possibility that it risks being outclassed in combat against bombers (if these still exist) by surface-to-air missiles of the *Bomarc* type for distant interception, or the *Nike* type for the defence of strongpoints. And it should not be forgotten that surface-to-air missiles, unlike strategic missiles, retain all their destructive ability against air targets, even if they are fitted with conventional high-explosive warheads. In Europe the space is too restricted to permit the use of the two weapons systems at the same time, and the difficulties of control and identification risk being such that the accumulation of fighters "in the rear," similar to that in the last war, will become impossible. Furthermore, all the pure fighters at present in existence are changing and becoming—as they have always done—fighter-bombers; the only exceptions are that the new F-104 or *Mirage III* will have undergone this change without ever having been used

Destined for USAF transport units, this C-130 *Hercules* STOL transport, at present undergoing tests, will have boundary layer control and high-performance flaps to give it a take-off run of 600 ft with a take-off weight of 100,000 lb.

as interceptors. This tendency to leave the role of high-altitude interception to non-piloted missiles and to retain the fighter aircraft for ground attack leads us to believe that the career of the Mach 2 VTOL might well be limited to the drawing-board.

This does not apply to the tactical fighter for use on the battlefield, either atomic or conventional, in either short- or long-range strike missions. Here the ideal would be a VTOL (or in the meantime a genuine STOL aircraft) which, in order to accomplish its mission successfully, should remain in the subsonic speed range.

This seems to be the latest thinking of the American Tactical Air Command, which has abandoned a Mach 2 VTOL in favour of a STOL operating at around Mach 1 and possessing a considerable range—in excess of 600 miles at low altitude. Furthermore, the term STOL is fairly broad in this case, as the requirement is for the aircraft to take off within 1,000 yards, a relatively simple matter with the power/weight ratios available today. Such a machine doubtless corresponds to the conception of a mobile force capable of operating almost immediately in any part of the world and able to make direct ocean crossings—if possible without flight refuelling. It is not within the scope of this article to discuss whether such a machine will be easy to achieve. At best, mention can be made of the difficulties facing a heavy aircraft (and such a machine will weigh a minimum of 25 tons), such as manoeuvres on unprepared airfields and even landing without becoming bogged in rainy weather. In fact it is obvious that if the VTOL aircraft necessitates the installation of cement blocks to support its weight and ensure its safe take-off at predetermined locations (similar to 1939 when the supplies were installed in advance on the operational airfields), the complete mobility which is essential to security will not be achieved, and the formula loses the greater part of its value.

This problem of complete mobility will not be solved merely by the disappearance of the runway. An aircraft such as that envisaged by TAC will have an enormous fuel consumption and will require a train of tankers for refuelling. Such a concentration would be in danger of immediate destruction. While satisfactory for certain aspects of conventional warfare, the Tactical Air Command STOL aircraft runs the risk of being difficult to employ in other situations. In Europe, for example, its radius of action is greater than necessary, and it appears that a light aircraft weighing about 7 tons would render far greater service. In fact, no advantage will be gained if the mobile base continues to grow while the fixed base disappears. Moreover, wherever the conditions of the theatre of operations permit the use of light equipment, we must not hesitate to seize this capital advantage.

Nevertheless, it is incontestable that in the tactical field the STOL aircraft, either light or heavy, will represent a major advance.

As its complement, it will no doubt be necessary to design and produce transport aircraft capable of using the same "landing areas." It is interesting to recall, in this connection, that this term, originally invented by Clément Ader, now comes into its own again. Ader even invented the "mobile landing areas," circular wooden structures quickly dismantled and transportable like those of a travelling fair. The day will come, perhaps, when we shall see VTOL aircraft take off from transportable circular metal "landing areas" made of special alloys capable of withstanding not only the weight of the aircraft but also the fierce jet efflux from the jet pipes. At all events, the application of the principle of vertical flight to all military aircraft becomes more and more pressing. Although more difficult to apply to certain categories than others, it will be an important step in the achievement of complete mobility. One of the results of this development, and by no means the least important, will, however, be the disappearance of the helicopter as an operational vehicle. Undoubtedly the helicopter will continue to exist in the form of a flying crane, for example, and in general for all applications where vertical flight is of greater importance than horizontal. But as far as purely military missions are concerned, such as that of assault transport, where it has been so useful in Algeria, the helicopter will one day be replaced by the VTOL aircraft.

The U.S. Army's Grumman *Mohawk* STOL reconnaissance aircraft (two 1,000 h.p. Lycoming T53 propeller turbines) can take off from grass runways and has maximum speeds around 275 knots. The range, with auxiliary fuel tanks, is 1,450 n. m. Normal overall flight endurance 2 hours; all-up weight 10,100 lb; two Martin-Baker ejection seats; side-looking airborne radar (SLAR); camera compartment; underwing pylons for anti-tank missiles and napalm bombs.

The Navy

But it is doubtless in the Navy that VTOL aircraft will bring the greatest changes. Short take-off is of no help on the small moving platforms presented by the fore and aft deck of naval vessels. Here more or less pure vertical take-off is essential. But what advantages it brings! Firstly, it will make it possible to dispense with the aircraft carrier, whose main disadvantage is that it constitutes a single basket of eggs of incredible cost. Despite its relative mobility (which is that of a tortoise compared with modern fighters, not to mention missiles), its very size makes it target No. 1 for an attacker, who will shrink from no sacrifice in order to send it to the bottom. At the present time the aircraft carrier is still necessary, despite the fact that it represents a concentration of power and investment which is disastrous in an age of dispersal and that the forces which must be deployed in order to defend it form a serious drain on the fleet. However, once every cruiser, destroyer or escort vessel can carry one or more aircraft capable of taking to the air at the first alert and of returning to deck on completion of their mission, the aircraft carrier will become unnecessary. Navies will be able to operate the same size fleet of aircraft as before, but they will be dispersed and hence much less vulnerable. Moreover, vertical take-off will do away with the need for lengthy manoeuvres to get the carrier facing into the wind, which so often wasted precious time. Admittedly, naval vessels may well have to be somewhat modified to meet the new air requirements, being equipped with platforms, hangars, fuel stores and assorted equipment, but in the overall view, the abolition of aircraft carriers and of bulky catapults will bring a valuable saving in weight and volume.

In the event of war, even merchant ships would easily be capable of carrying reconnaissance and anti-submarine aircraft, the latter for the type of warfare which still presents the admirals with the most formidable problems. The paramount advantage of the VTOL aircraft over the wartime catapult aircraft is that the latter can be used only once from its parent vessel. Similarly, VTOL aircraft will be more suitable for search and rescue missions, both at sea and on land, than the slow and vulnerable helicopter. Finally, even submarines—which, diversified, specialized and enlarged, will be the capital ships of tomorrow's war—could with advantage carry small VTOL aircraft.

Obviously the organization of the fleet air arm will have to be modified to fit the new conception. But progress in communications will enable aircraft to take off simultaneously from a number of ships and form up much more quickly than hitherto. Similarly, there will no longer be any need for the interminable waiting to land after a mission, which has so often led to disaster in the past. To sum up, the introduction of VTOL aircraft will mean the replacement of one large base by a multitude of small dispersed bases, whose small size and relative mobility will ensure far greater protection against fatal nuclear attack than all the active defence systems.

The future

It is still too early to say what technical methods will ultimately be adopted in order to obtain vertical take-off. But it is already possible to foresee what general direction must be taken to give the aircraft—the ultimate in means of transport, whether for weapons, passengers or cargo—total freedom of movement both in its own medium, the air, and in its contacts with its base, the ground. Service aviation at any rate is moving towards the machine capable of carrying out the most varied manoeuvres, of moving vertically and horizontally, backwards, forwards or sideways, within a speed range running from zero to ever-increasing maximums, and with acceleration potentials (positive and negative) which will confer on it an infinite flexibility and enable it to carry out any kind of mission with the greatest efficiency.

Admittedly, all this is not for tomorrow. In the meantime, military experts must concentrate on solving the question which is the most urgent today, namely of allying the qualities of the helicopter with those of the conventional aircraft, while avoiding the defects of each. At the most, they can hope that the overall problem of obtaining greater mobility should be treated as a whole and not limited to the aircraft domain. There would be no use in having a machine capable of taking off and landing vertically if it must first have a special platform, however small, or if it were to be condemned, for lack of fuel or ammunition, to remain on the ground where it would soon be destroyed.

Let us take heart. An operational problem is a complete entity which working groups normally examine in full detail before drawing up a programme. Thanks to the VTOL aircraft, giant air bases will soon be a thing of the past, and the improved air forces will be in a better position to fulfil their highly important missions, no matter what form a future war may take. ⟶

Fairey *Rotodyne* (two Napier *Eland* turboprops, two compressors and four blade-tip jets), the first operational VTOL airliner, is being built in an advanced version, with *Tyne* propeller turbines, by Westland Aircraft Limited. The prototype was recently fitted with a third, central, fin.

Survey of Short and Vertical Take-off Aircraft

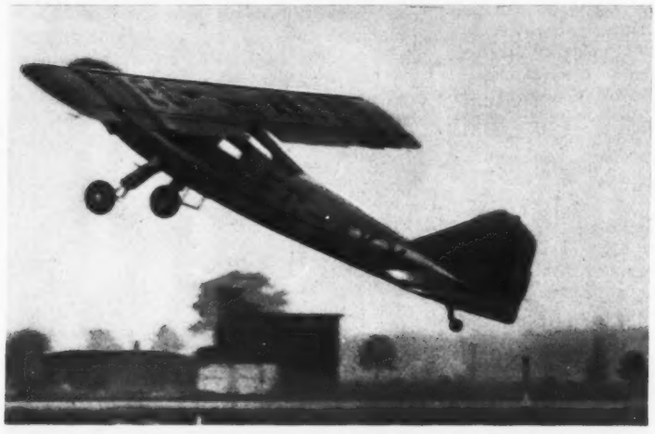
The pre-war Fieseler *Storch* (240 h.p., gross weight 2,640 to 2,770 lb, wing area 280 sq.ft) was an efficient STOL aircraft.

Subject and title first require some explanation: why not limit the present review to the true vertical take-off aircraft? Why include also the short take-off models?

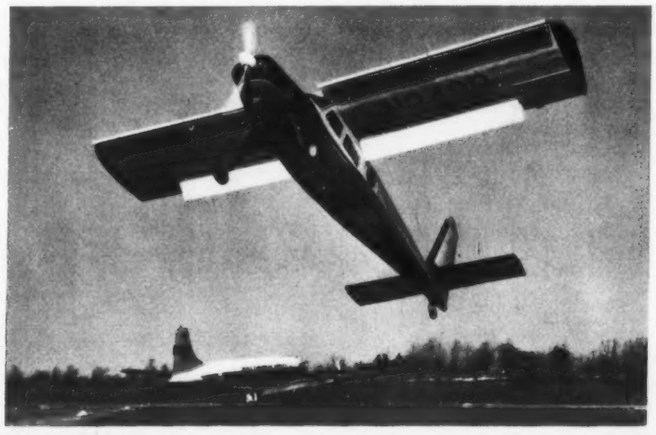
Here the views of the projected users of the new equipment, namely the military services and short-haul carriers, are decisive. Both groups attach far less importance to balloon-like vertical take-off than to the ability to use "the smallest possible make-shift landing grounds" . . . a notion which will be defined later. As a rule they have no objection to a take-off run of a few dozen yards, as even the pure vertical take-off types will be able to manoeuvre under their own power on their bases.

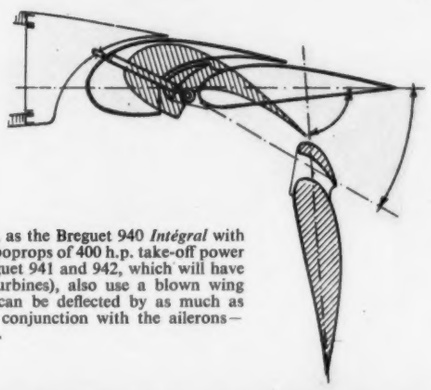
The ability to lift off immediately (i.e., the requirement for the shortest possible take-off run)—which incidentally was a feature of many of the "string-and-sealing wax" contraptions during the early years of flying—is

After the war the *Storch* configuration was taken up again in modernized form in the Dornier Do 27 (picture shows a prototype in Spanish colours) . . .



. . . and in the American Helio *Courier*. Both aircraft have high-lift flaps and full-span slats.





Larger STOL aircraft, such as the Breguet 940 *Intégral* with four Turboméca *Turmo* turboprops of 400 h.p. take-off power each (prototype of the Breguet 941 and 942, which will have more powerful propeller turbines), also use a blown wing with high-lift flaps which can be deflected by as much as 90 degrees and which—in conjunction with the ailerons—extend over the whole span.

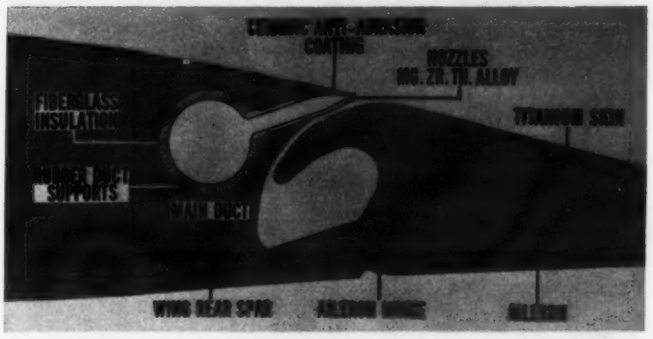
in fact of secondary importance. The decisive factor is the ability *to lift off steeply*, and this quality depends primarily on the relationship between power and weight, or in other words on the engine power, in h.p. or pounds of thrust, per pound of aircraft take-off weight.

Steep angle take-off becomes easier to achieve the smaller and lighter the aircraft is. The old Fieseler *Storch* (Fi 156), of between-the-wars fame, was an extraordinarily efficient STOL aircraft, since it took off (no wind) in 195 ft with a gross weight of 2,640 lb, climbed at 945 f.p.m. with a forward speed of 35 knots and required a power of only 240 h.p. or 0.09 h.p./lb. Very large STOL aircraft, on the other hand, such as the Lockheed C-130 *Hercules* BLC transport (with high-efficiency flaps and boundary layer blowing) developed for the USAF, need as much as 0.25 h.p./lb, to achieve a take-off run of 600 ft at a gross weight of 100,000 lb. Finally, in the case of the first operational VTOL transport, the Fairey *Rotodyne*, the installed power per pound of take-off weight is probably nearer 0.45 h.p. (the extra power available during vertical take-off can only be roughly estimated, since the thrust of the four blade-tip jets has not been announced).

The first general rule thus emerges: the higher the take-off weight and the steeper the initial angle of climb, the more rapid is the increase in the effective take-off power required per pound of weight.

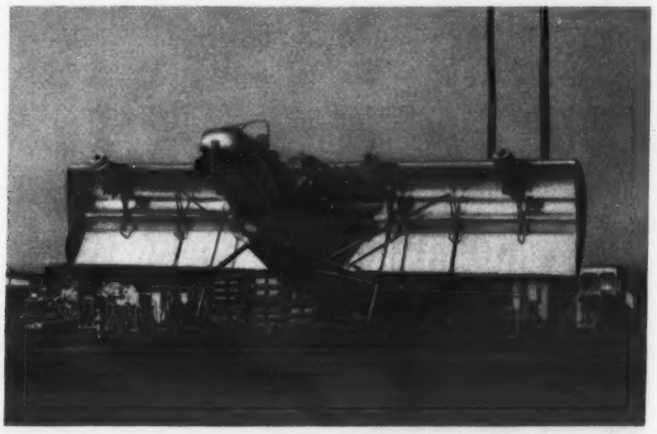
The second, somewhat less obvious rule is as follows: the take-off power required also depends to a very important extent on the efficiency of the overall propulsion and flow deflection system. A good degree of efficiency in turn depends on obtaining the lowest possible velocities for both the propulsive and the lifting stream. The following are the principal methods of achieving vertical or short take-off, graded in order of rising stream velocities and falling efficiency in V/STOL flight:

1. Rotary wings (rotors) with mechanical or jet propulsion;
2. Propellers with fixed axes at a small angle of attack and slip-stream deflection by aerodynamic means (wings with slotted flaps or blowing slots);
3. Shrouded propellers with fixed axes and internal flow deflection by means of cascades of blades (the aerodyne concept);
4. Shrouded propellers with axes swivelling through roughly 90 degrees (Doak concept);
5. Unshrouded propellers with axes swivelling through roughly 90 degrees, with fixed or swivelling wing;



By contrast, the latest version of the Lockheed C-130 *Hercules* uses boundary layer control on the landing flaps and ailerons (and on elevators and rudder). Here too the flaps can be deflected by a full 90 degrees (lower picture). The BLC air is supplied by two outboard Allison YT56-A-6 compressor engines and fed via insulated ducts to ceramic-lined slots; the aileron and flap skin is of titanium sheet.

Several designers have pursued development of the principles illustrated in the left-hand row of pictures to the point where they have arrived at an ultra-light (single-seat) V/STOL aircraft with stubby wings and full-span flaps lying entirely in the propeller slipstream, plus wing-tip discs to prevent lateral break-away of the deflected slipstream. The Fairchild VZ-5FA experimental model, with four propellers covering the entire span, and General Electric T58 shaft turbine; left, in cruising condition; right, during take-off.



The Hiller X-18 tilt-wing army transport, powered by two Allison YT40 turboprops and contra-rotating propellers, cavorts in the skies above Edwards AFB, California, like any normal fixed-wing aircraft. This first test phase is to be followed by transitions to hovering attitude and back to normal, with full 90-degree tilting of the wings and engines at moderate altitudes; finally, vertical take-offs are also planned.

A total of 21 test flights was made by the Ryan VZ-3RY before it crashed, covering in particular hovering flights at low altitude (100 ft) and medium height (3,700 ft). Lift-off speed was 22 knots (after a run of only 30 ft), and landing speed 17 knots. Full-span flaps; Lycoming T53 shaft turbine with two simple propellers.

Vertol 76 (VZ-2) tilt-wing aircraft, with Lycoming T53 engine and two propellers, making a slow S turn shortly after take-off.

6. Lift-producing blowers with fixed axes at a large angle of attack (practically perpendicular);
7. Turbojets with axes swivelling through up to 90 degrees or with jet deflection (bent and/or rotating jet pipes; rotating louvre-type nozzles; Coanda flaps; jet flaps);
8. Perpendicularly mounted turbojets, in the tailsitters or the flat risers (with dual propulsion).

The present survey of V/STOL models which are already undergoing tests (or about to begin them) follows in broad outline this spectrum of propulsion categories. Pure helicopters or gyroplanes and the various hovercraft or ground effect machines have not been included.

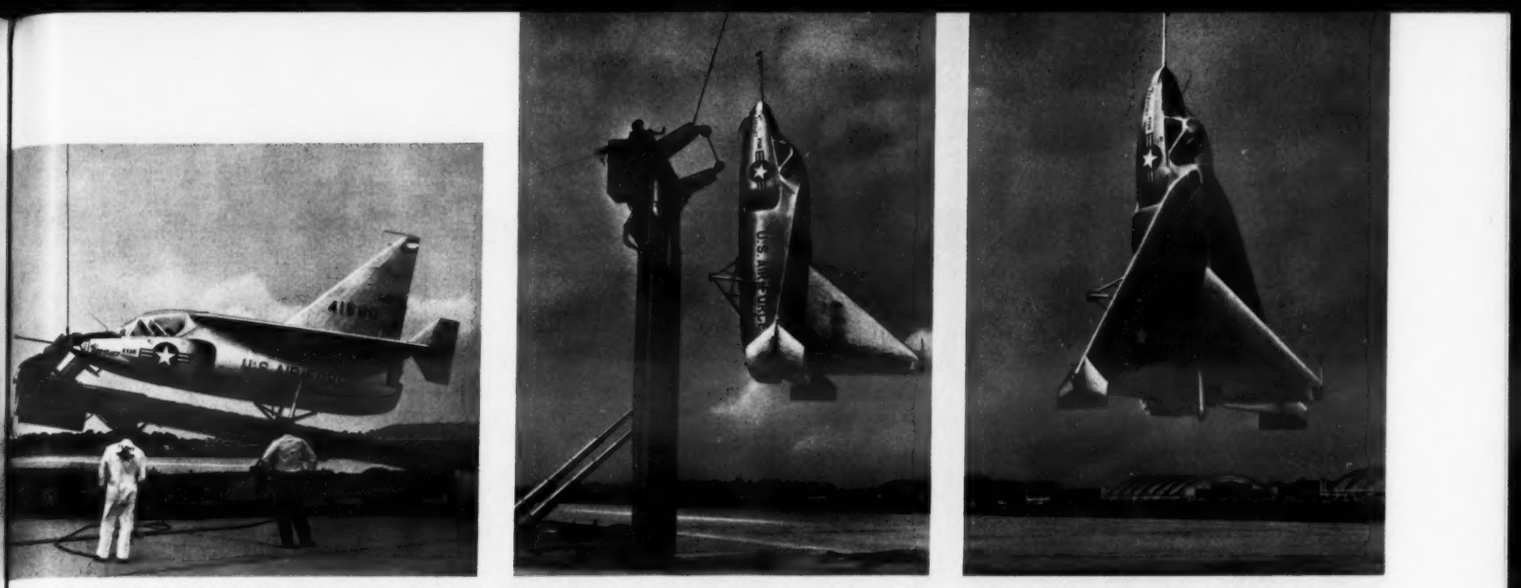
To prevent the erroneous opinion from arising that preference should always be given to that propulsion category which offers the lowest installed power requirement per pound of aircraft weight, a third general rule must now be introduced. This is as follows:

Quite apart from vertical or short take-off qualities, the military V/STOL machine must also have suitable cruising and combat speeds and be able to achieve the required range. Civil V/STOL equipment is required to have an economic transport capacity, i.e., a high payload capacity at good cruising speed. This makes the projected cruising speed of the V/STOL aircraft into a decisive factor. It transpires that propulsion category No. 1 (the *Rotodyne* formula) can be applied only up to a maximum of 200 knots, and that categories Nos. 2 to 5 permit of maximum speeds of some 400 knots at the utmost. For still higher design speeds, therefore, the propulsion system must from the outset be chosen from among categories 6 to 8.

Added to this is the fact that high flight speeds, particularly in the supersonic range, require disproportionately high cruising powers, which automatically increases the available take-off power. For example, the take-off thrust loadings of most of the United States Century Series of fighters and the B-58 *Hustler* and A3J *Vigilante* supersonic bombers with afterburners

Doak X-16 experimental VTOL aircraft, with Lycoming T53 in the fuselage and parallel rotating ducted eight-blade propellers. The propeller axes are vertical during take-off and landing, horizontal during cruising flight; for climb they can be tilted 45 to 60 degrees forwards and for braking purposes slightly backwards.

The port ducted propeller in the Doak X-16 and the exhaust control system in the tail. In front of each eight-blade fixed-pitch propeller are 14 variable guide vanes which act as ailerons in the hovering condition. The cruciform vanes in the turbine exhaust flow provide pitch and directional control and are of stainless steel.



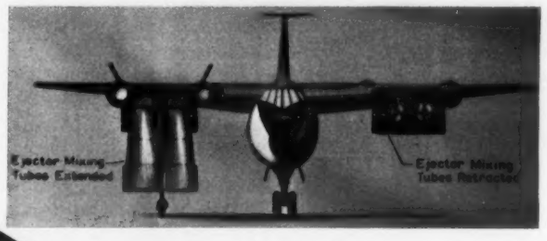
The Ryan X-13 "tailsitter" (Rolls-Royce *Avon* jet) made astonishing take-offs from its special erectable platform. It also succeeded in making the transition to level flight on several occasions and in hooking itself back onto its rig. However, piloting the aircraft proved so difficult that development had to be abandoned.

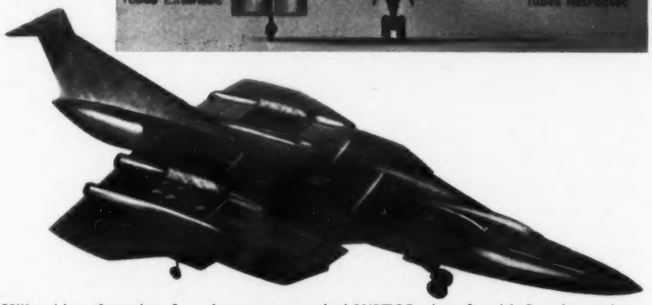
in operation are already between 1.25 and 2 lb/lb, which amounts to a power requirement of between 0.99 and 1,36 h.p. per pound of take-off weight, depending on lift-off speed and efficiency. And for Mach 3 aircraft a take-off power of some 1.8 to 2.73 h.p. per pound will probably have to be provided. It will therefore be seen that, with rising cruise Mach number and correspondingly growing engine power, short or vertical take-off capability might well be achieved—despite simultaneously increasing take-off weight (due to increasing fuel requirements)—as a kind of by-product . . . of which the designer merely has to take advantage. The order in which the present survey is arranged therefore also gives the basis for a systematic classification of V/STOL aircraft in order of cruising speeds, from low subsonic to high supersonic.

•

The above considerations would seem to justify the claim that the future in both service and civil aviation belongs to the jet-supported V/STOL supersonic aircraft, which will either have an extremely small, sharply swept delta wing or dispense altogether with aerodynamic support surfaces. This is the conclusion which David Keith-Lucas and Dr. Alexander Lippisch (see the following articles) have reached. These aircraft of the future will most probably have to be designed as flat risers, with the pilot occupying much the same position as a rider on his horse, rather than as tailsitters which carry him in a back pack. As the testing of the Ryan X-13 *Vertijet* and the *Coleopter/Flying Atar* revealed, the difficulties of flying the tailsitters are extremely great.

The main role in the development of jet-supported V/STOL flat risers is, of course played not by the airframe designers but by the engine manufacturers. They are expected to provide the lift blowers, flow deflection systems, mixing nozzles and other jet control devices, which must function perfectly at high operating temperatures and still add only little to total structural weight. And for V/STOL aircraft for higher supersonic Mach numbers, whose propulsion engines must be designed to make the maximum use of the





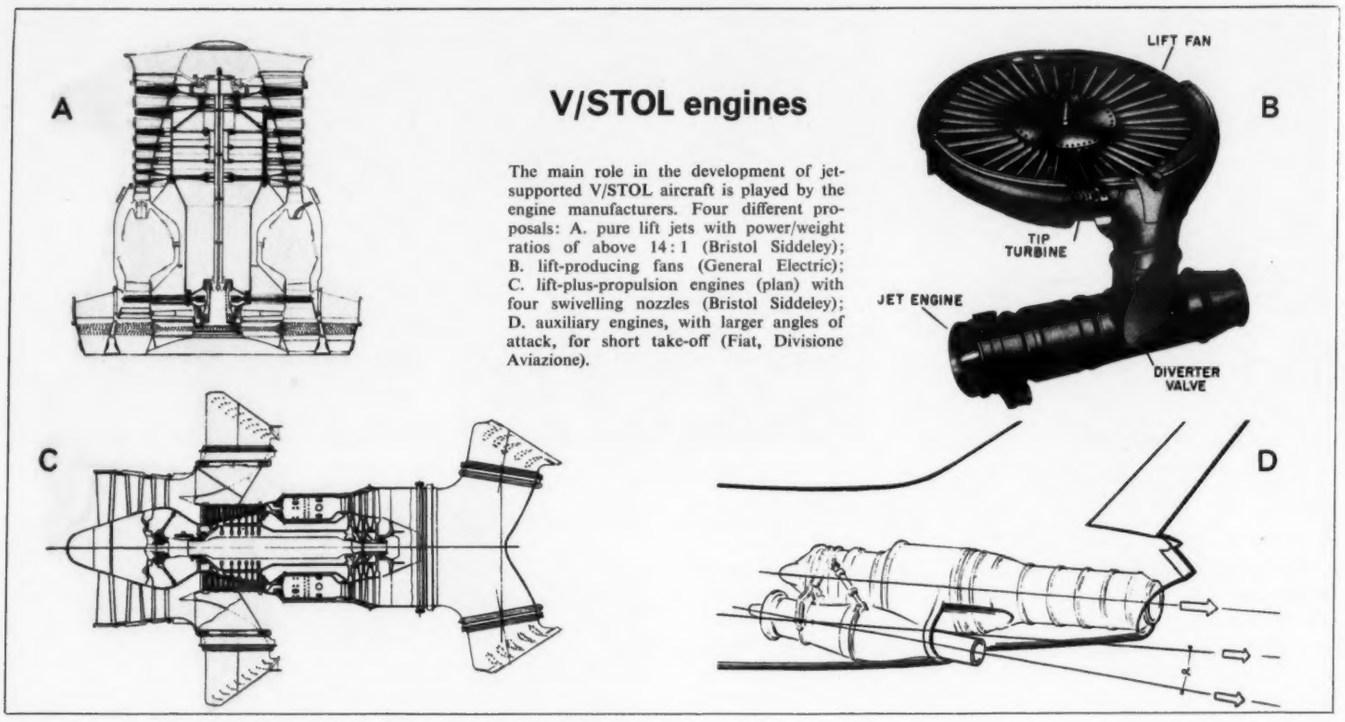
Hiller Aircraft project for a long-range tactical V/STOL aircraft, with four jet engines. Jet deflection is used during take-off and landing, and external air is passed through 16 mixing nozzles in the wings to give an ejection effect. The mixing nozzles are covered during cruise, and their extensions beneath the wing are retracted.

Four vertically mounted lift jets and one propulsion jet, all five of Rolls-Royce RB.108 type, power the Short SC.1 experimental VTOL aircraft. First transition flight was made on April 6th, 1960.

Using a new type of unshrouded propeller, Curtiss-Wright Corporation plans to develop three prototypes of VTOL convertiplanes, including a six-seater with extremely small tandem wings dimensioned purely for high-speed cruise. Each propeller is driven by a tilting turboprop. The designers expect a vertical climb capability to an altitude of 20,000 ft and cruising speeds of around 350 knots.

V/STOL engines

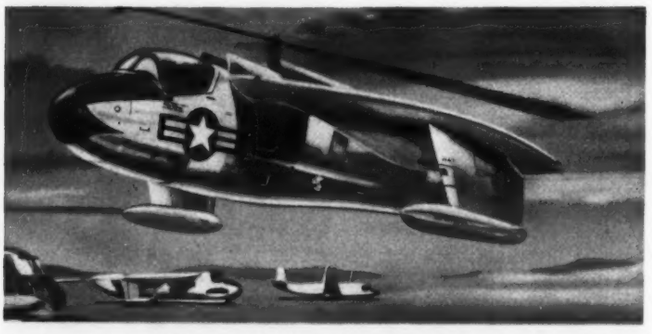
The main role in the development of jet-supported V/STOL aircraft is played by the engine manufacturers. Four different proposals: A. pure lift jets with power/weight ratios of above 14 : 1 (Bristol Siddeley); B. lift-producing fans (General Electric); C. lift-plus-propulsion engines (plan) with four swivelling nozzles (Bristol Siddeley); D. auxiliary engines, with larger angles of attack, for short take-off (Fiat, Divisione Aviazione).



ram effect and can therefore deliver no appreciable static thrust, the designers will have to await the development of particularly lightweight lift engines and use them in batteries to provide vertical thrust. The general impression created is that both lines of development have made promising starts, but that it will be another few years before operational engines are available.

A number of aircraft designers are, however, already engaged in preliminary studies and experimental developments for jet-supported tactical V/STOL aircraft. This work is either based on existing special engines, such as the Bristol BE.53 (a by-pass jet which can be fitted with four rotating nozzle grids) and the Rolls-Royce RB.145 or RB.153 (lightweight lift jets), or is being carried out in anticipation of the development of a General Electric secondary lift engine derived from the turbofan formula (CF-700 or CJ-805-23).

European efforts appear to be directed towards the design of a "third generation" NATO strike fighter to succeed the Fiat G.91. The projects falling within this group are unlikely to exceed 6 to 7 tons in gross weight. On the other side of the Atlantic, however, the SDR-17 specification (System Development Requirement No. 17) recently issued by Tactical Air Command is for a V/STOL low-level strike aircraft with very long range. Here gross weight will probably be nearer 25 tons, although the aircraft must still be capable of taking off and landing in less than 3,000 ft. The former task is being tackled by Short and Hawker in Britain; Sud-Aviation, Nord-Aviation, Dassault and Breguet in France; Fiat's Divisione Aviazione in Italy and the Entwicklungsring Süd in Germany. Main development work on the USAF tactical aircraft is taking place at Bell Aircraft, Boeing, Republic, Hiller, Lockheed and Douglas. The accompanying pictures show some of the few known development projects.

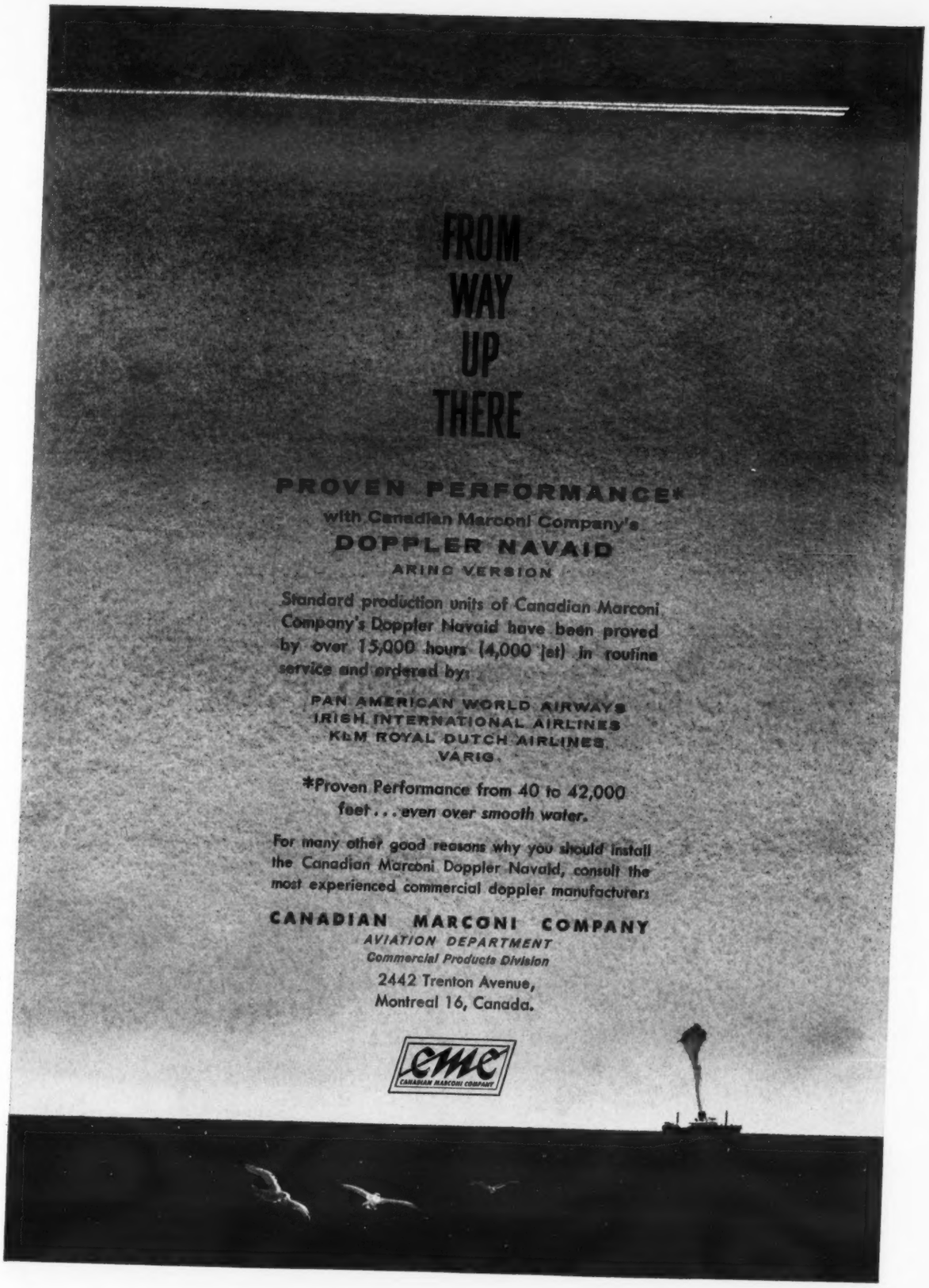


Finally, two original designs for V/STOL aircraft: *above*, the Sikorsky S-57 project with single-blade rotor for take-off (driven by three compressed air jets at the blade tip and later retracted into the fuselage) and Pratt & Whitney J52 propulsion engine for high-speed flight; *below*, the *Vanguard* project proposed by Vanguard Air & Marine Corporation for a helicopter-aircraft combination with countersunk rotors and pusher propeller (power supplied by a 265 h.p. Lycoming engine).

*

Until such time as supersonic V/STOL aircraft become operational, the aircraft of the other propulsion categories will no doubt maintain and perhaps strengthen the positions they have won in their speed classes. Once introduced, they will doubtless hold their own in certain very specific domains even in the more distant future. After all, there is no reason why, even in ten or twenty years' time, a Fieseler *Storch*, a Helio *Courier* or a Do 27 should not meet the needs of a flying doctor visiting patients in scattered settlements, whether it be in Australia, Africa or South America. The same applies to commercial aircraft patterned after the Fairey *Rotodyne* or the Breguet *Intégral*, which could still be used on short stages (though probably not from city centre to city centre) and to the myriad configurations for V/STOL Army close reconnaissance and communications aircraft, such as, for example, the Grumman *Mohawk*.

How small a "small make-shift landing ground" must be, in other words exactly how a "short" take-off should be defined, has still not been finally settled. The best solution will probably be to fit the standards selected to the different applications of V/STOL aircraft. While a military communications aircraft or a small STOL transport should be able to take off and land at sea level on a grass runway measuring some 500 to 650 ft and surrounded by obstructions 50 ft high, STOL strike aircraft and heavier STOL military transports will require somewhat more generous criteria, say 1,500 to 3,000 ft concrete runways. The requirements for future jet-supported VTOL supersonic aircraft will probably be of the same order, if only to avoid hot exhaust gases damaging the concrete or metal runway surface. ←←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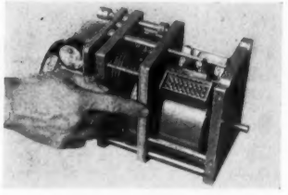

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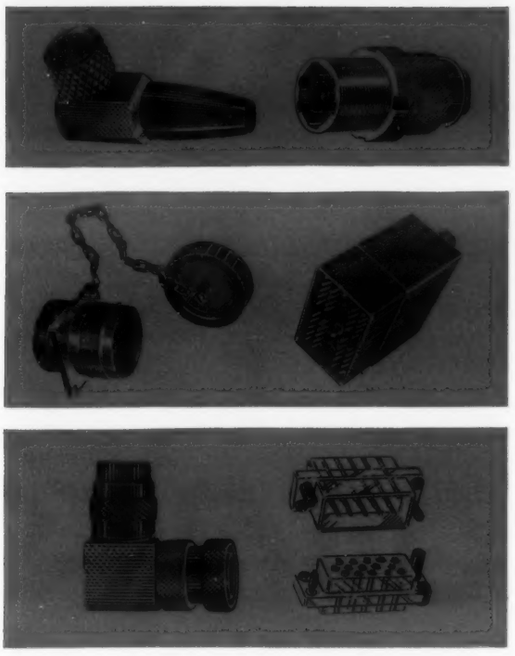

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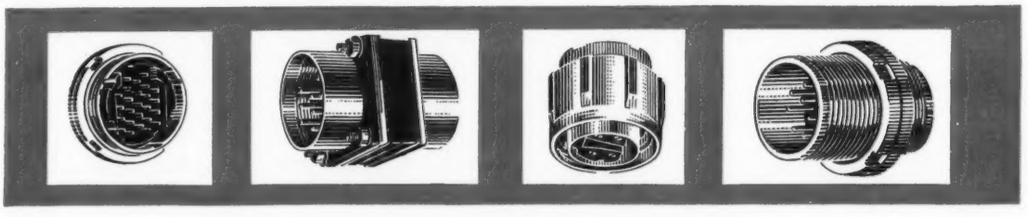

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Jet Lift for Supersonics

By David Keith-Lucas,
Technical Director,
Short Brothers & Harland Limited,
Belfast

The Short SC.1 VTOL research aircraft in vertical climb, shortly after take-off.

Much effort has been expended on arguing the merits of various lifting systems for vertical take-off and landing—helicopter rotors, propellers, fans, jets or rockets. It is now becoming increasingly obvious that the different systems each have their different roles, the main discriminant being the cruising speed. They are no more rivals than the delta wing is to the wing of high aspect ratio. There are, of course, possible compromises. One does not have to choose between a narrow delta and an aspect ratio of 12 but can optimize the aspect ratio for the particular design. So also one need not choose between a pure jet and a fan but could use a bypass engine and optimize the bypass ratio—if it would give any advantage.

The crux of the matter is the efflux velocity; the lower the efflux velocity, the less the power required and the fuel consumed in hovering flight—the higher the efflux velocity, the smaller in general is the lifting system and the drag in forward flight. For high speed aircraft which have to hover or fly at very low speeds for any length of time, the power and fuel consumed are the governing factors.

So it is that the helicopter is pre-eminent in the role of air sea rescue, submarine detection, aerial crane and on routes which are so short that cruising speed is unimportant. At the other extreme the rocket is pre-eminent for interplanetary and all extra-atmospheric flight. For supersonic flight in the atmosphere there is at present no answer other than pure jet lift. Propellers and fans could fit into the subsonic picture.

This would be very neat and tidy if the weight per horse-power of all engines were the same. However, propeller engines and fan engines are not only heavier per horse-power than pure jet engines but, when the whole installation is taken into account, are actually heavier per pound of thrust even when we include the fuel for take-off and landing.

On present evidence it looks as if the optimum bypass ratio is two or less. Certainly on performance grounds there is a poor case for either propellers or fans. Their advocates claim, however, that they have an advantage due directly to their efflux velocities. It is argued that a jet of high velocity is an uncomfortable thing to live with especially if it is hot; it is not only a source of much noise but it also gives rise to ground erosion and demands some sort of pad or platform for take-off and landing.

The importance of these points is easily exaggerated. No turbine driven aircraft is likely to be quiet enough for city centre operations, and, when operating from aerodromes, the jet VTOL aircraft will make less noise nuisance than a conventional jet aircraft mainly because of its steeper climb and approach angles. Ground platforms are relatively cheap and small and are an insignificant part of the cost of an air terminal. Even in forward military areas they could be transported by lorries and assembled in a matter of minutes.

The harsh fact is that up to date the hardest problem in VTOL is to get sufficient range and payload. The question is whether there is a case for developing propeller and fan lift aircraft or whether, due to its superior performance, the jet with or without some bypass is not better suited to fill all the roles between the helicopter and the space rocket.

Before trying to answer this we must look more closely at the jet lift aircraft. About six years ago A. A. Griffith propounded his ideas of a jet lift, narrow delta, supersonic, civil airliner. His claim was that the lifting engines could be so light that the penalty of installing them would be less than that of making the aircraft suitable for conventional take-off and landing. The aircraft could be made the right shape for supersonic flight, the propulsion engines could be designed for high speed without compromise with take-off requirements, and many subsidiary advantages would follow such as lower fuel reserves, reduced undercarriage weight and elimination of flaps and brakes. As a result he prophesied a performance advantage for the jet lift aircraft, which is to say that a supersonic airliner with jet lift would weigh less than a conventional aircraft to do the same job. This was a staggering claim in view of the obvious dead

weight of lifting engines which contributed nothing to the flight except at take-off and landing.

Let us be honest and admit that nearly all of us thought the idea brilliant but unrealistic and when we came to make sketch designs and put the figures in we only confirmed our suspicions. We could not get the figures to add up to a profit, and the conventional aircraft still seemed to be the better.

But we underestimated the engine companies. In the last five years the improvement in the specific weight of jet engines has been remarkable. Six years ago it was only the brashest who dared to dream of ten pounds of thrust per pound weight. Now we are looking forward hopefully to fourteen—fifteen—sixteen—?

The scheme depended too on the aerodynamic merits of the slender wing configuration and on the structure weight which could be achieved. In both these fields the results of recent work give ground for hope. Above all it depended on solving the stability and control problems, and it was for this reason that the Short SC.1. was designed and built. That is why it has a delta wing and separate lift and propulsive engines. In designing it we had one eye on the Griffith narrow delta. We also had the other eye on the more immediate military applications such as low level, strike/reconnaissance aircraft, naval strike fighters and high speed transports for military use.

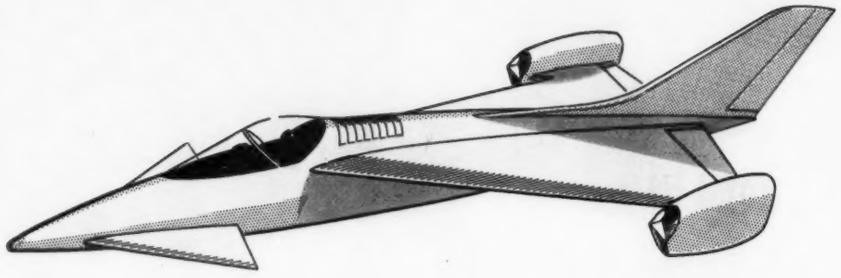
There is a real need for such military aircraft which can operate in complete independence of runways. Runways are vulnerable, slow to construct and often located much too far from the scene of battle. VTOL overcomes these difficulties and adds the benefit of wide dispersal, but it still will not be acceptable until it can be achieved without prejudice to performance.

The same is true in the Navy. VTOL offers the possibility of operation from all ships and avoids the dangerous concentration of all the air power in a few carriers. It permits operation when the ship is steaming into wind, down wind, across wind or is at anchor. It takes the risk out of deck landing. But again it will not be acceptable until it can be achieved without prejudice to performance.

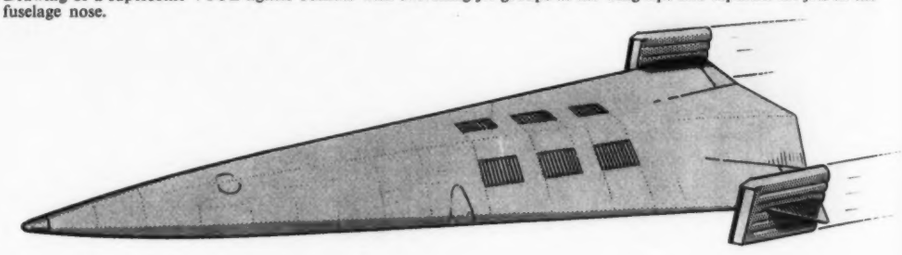
This is a realistic attitude to adopt because aircraft of second rate performance can never establish air superiority over better aircraft even though they outnumber the enemy by ten to one. Britain owed her survival to this fact just twenty years ago.

VTOL aircraft will come into operation in a few years' time, but in the meantime there will be advances in the performance of other aircraft. It would be the greatest folly therefore to embark on VTOL designs which are limited to subsonic performance. This eliminates fan lift, and we are led to the inevitable conclusion that jet lift is the most important form of VTOL on which to concentrate, both for its civil and military potentialities.

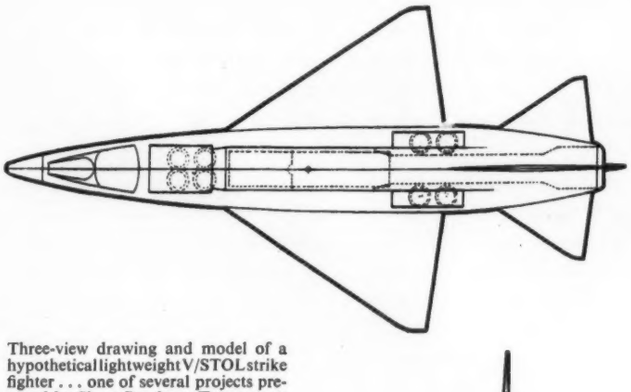
There is still a great deal to be done before these possibilities are realised. The SC.1. is exploring the engineering problems especially of stability and control. Following the Griffith conception it has separate lifting and propulsive engines. This arose because the Griffith

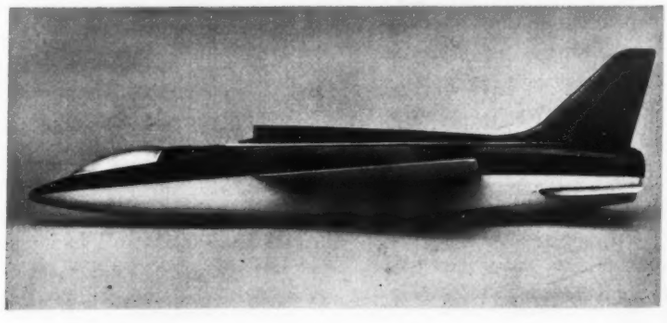


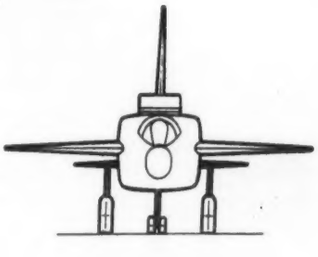
Drawing of a supersonic VTOL fighter-bomber with swivelling jet groups at the wing tips and separate lift jets in the fuselage nose.

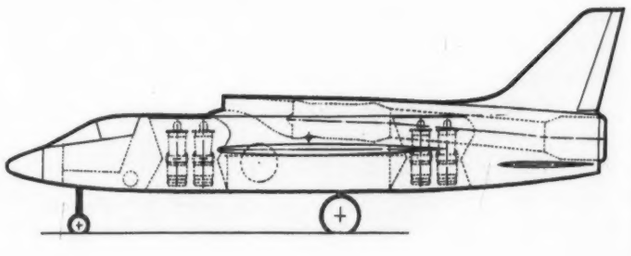


Drawing of a supersonic VTOL airliner with narrow delta wings, fixed propulsion units and six batteries of independent lift engines.









Three-view drawing and model of a hypothetical lightweight V/STOL strike fighter . . . one of several projects prepared by Short Brothers. Two groups of four vertically mounted lightweight jet engines supply lift, while a turbofan with afterburner is used for propulsion; the stabilization system for hovering and transition would be similar to that in the SC. 1. Projected Mach number at sea level 0.98; supersonic speed at higher altitudes; radius of action at low level with a one-ton military load around 220 nautical miles.

delta was conceived for speeds of M = 2.5 or 3, and at those speeds the propulsive engines will get most of their compression from ram pressure and will, in fact, be not far removed from ramjets. They will not therefore give much static thrust.

At intermediate supersonic speeds the position is quite different. Engines capable of providing a top speed of M = 1.5 to 2.0 are likely to give a static thrust comparable to the all-up-weight of the aircraft. We cannot afford not to use this thrust for take-off so we must find means of deflecting the jets vertically downwards. Many schemes have been suggested, including swivelling engines either at the wing tips or in pods, a two way tap in the jet pipe to deflect the gases through a branch pipe, a jet pipe which deflects by rotation about a skewed axis or the bifurcated jet pipe and rotating nozzles as used on the Bristol BE.53, which method need not be confined to fan engines. Engineering experience is needed on these as they must be made reliable if vertical landing is to be operationally useful and not just an optional luxury. It is not an easy problem as most forms of jet pipe deflection involve an airtight precision bearing which must run red-hot.

Equally important are the safety and reliability aspects associated with reliance on automatic stabilization. This problem is, however, being tackled on the SC.1. and is part of the purpose of that aircraft. A fully triplicated system complete with fault detection has been developed, and the engineering difficulties are now well understood.

A VTOL aircraft is only part of an operational system. Operational techniques must be worked out, blind landing systems developed, ground equipment must be designed and made, maintenance problems must be studied and so also must training methods. Some of these problems can be worked out on an experimental aircraft, and considerable advances have already been made on blind landing systems and ground equipment. Most of the other problems can only be solved by getting VTOL aircraft into the hands of the Services as soon as possible. These aircraft should have truly vertical take-off and landing capability and preferably STOL capability also. The obvious type to employ would be a development of the SC.1 with jet deflection or engine tilt on the propulsive engines. The next generation, employing newer and better lift engines, should be a fully operational supersonic type. With this and the supersonic airliner before us there seems little point in dissipating our effort on propellers and fans with their limitations to subsonic speeds. ←←

V/STOL and the Ground Support Aircraft

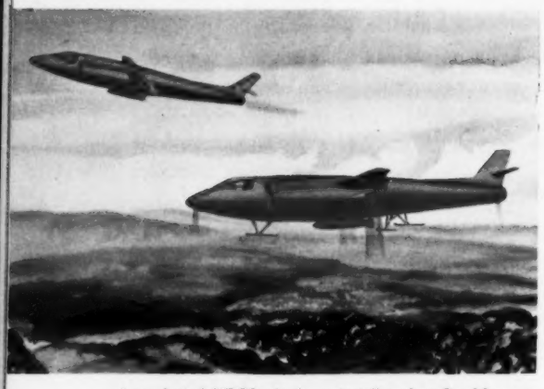
By R. S. Hooper, Project Office, Hawker Aircraft Ltd., London

The author stresses that the ideas expressed in the following article are entirely his own. Yet it should not be forgotten that he is a member of the Project Office of Hawker Aircraft Limited under Chief Designer Sir Sydney Camm, which has been working for several years on the development of a V/STOL strike aircraft. Although the first flight of the Hawker P.1127 (one Bristol BE.53 ducted fan engine) is scheduled for the coming summer, little or no information on this aircraft has been released to date. In undertaking the project, Hawker doubtless was thinking of the NATO requirements for a third-generation strike fighter, while the British Minister of Aviation hinted at the end of 1959 that this aircraft category meets the needs of the RAF. *Editors*

Any reader of *Interavia* has been kept well informed of the trend of development of the European lightweight strike aircraft and also of the progress on both sides of the Atlantic towards the goal of jet-borne vertical take-off. The latter presents two great areas for work and achievement, one the engineering problem of installing sufficient thrust in an operational aircraft and of endowing it with stability and control throughout its transitional speed range, the second, the operational task of learning how to make the maximum use of such an aircraft with its entirely new capabilities and problems. A great deal has already been written on the first of these topics, and now that the engineering problems are giving way before achievement it is time to study the implications of the operational environment in the design of a tactical strike/reconnaissance aircraft. In short, to combine the two developments mentioned in the opening sentence.

The reasons for the continuation of the strike aircraft in the European theatre were well summarised by General Gallois in his article "The Light Strike Fighter for the Defence of Europe" in *Interavia* No. 1/1958. Little need be added except that the likelihood of any recognizable airfield remaining intact, in the event of conflict, has decreased as the tactical missile has progressed. Hence the demand of the late 1950s for STOL will become the early 1960s' requirement for VTOL.

A second type of warfare for which these aircraft are suited is the small war or police action. Here long ferry range with the ability to operate at short notice in any part of the world with any type of armament is of paramount importance. Only the V/STOL aircraft can guarantee to operate in close support wherever it is required. In this connection the importance of the ability to perform an overload short take-off, or even a conventional take-off, at the commencement of a long range mission should not be overlooked. Not all the solutions offered to the problem of V/STOL have this ability. The tail sitters cannot do it, and of the flat risers the type with a proportion of fixed lifting engines is inferior to the vectored thrust or tilting engine solution. A final word on STOL—the definition proposed some years ago, for aircraft of the generously flapped, low wing loading, propeller driven type, of 500 ft take-off distance to 50 ft height is unrealistic in the present context. It can easily be shown that the low level, high speed, jet aircraft requires a thrust/weight ratio closely approaching unity in order to achieve 50 ft within this



A projected VTOL single-seat strike aircraft with combined lift/thrust jet engine and very small wings, as proposed by Dr. Hooker, of Bristol Siddeley Engines Ltd. In the top left-hand corner the aircraft is shown in fast, low-level flight, when the wings are just capable of supporting it.

distance. The parameter that should be defined is the permissible ground roll, and here very short runs will greatly decrease the load that can be lifted off.

Before looking at the problem of operating a V/STOL strike reconnaissance aircraft we may look briefly at its required performance. To be acceptable it should obviously be superior in both speed and range to the aircraft it will replace. We do not wish to remove it from the tactical to the strategic role, so that a large increase in low level range will not be necessary. But speed? Already there are operational aircraft flying at Mach 2. Can any Air Staff resist the temptation to require a top speed of this order for a new aircraft to come into service in the 1960s?

The laws of Nature force the choice between Mach 1 and Mach 2 with no very useful compromise in between. If supersonic speed is a must, it will be provided, but at a cost in weight, complexity and expense. The problem is really to minimize the vulnerability of the aircraft to the combination of enemy defences and natural hazards, by a correct choice of cruising speed and height above ground. Increasing height exposes the aircraft to a greater likelihood of successful enemy countermeasures. Increasing speed from high subsonic to supersonic, at low level, acutely increases the problems of navigation and obstacle avoidance. As an illustration of the latter an aircraft flying level at M = 2 and initially at 500 ft will crash in less than 3 seconds if the ground begins to slope upward at 5°. The danger of sudden obliteration of vision due to flight through insect swarms and gradual diminution due to sand particles if over desert is likewise increased, and to these must be added the damage due to rain or hail which is already serious at high subsonic speeds. The automatic terrain clearance system—if it depends on a forward looking radar—will not be improved if the radome is being rapidly eroded by rain. To all this should be added the problem of the degree of roughness of the low level ride which the pilot—and the automatics—can accept and still remain in charge of the situation. This problem again is already difficult at high subsonic speed. The tactical aircraft will often be employed to attack targets of opportunity or it may need to search for a target only loosely positioned by previous reconnaissance. On such occasions rocket armament, either guided or unguided, would probably be used. Both search and accurate delivery would place a very definite subsonic limit on aircraft speed. Perhaps, without putting any numbers to the problems enumerated, enough has been said to indicate that, even under conditions of good visibility, the pilot will choose to cruise and attack subsonically. Under blind or bad visibility conditions, which any aircraft operating in Europe must often meet, speeds will be even further curtailed. Of what use then is high supersonic performance for the tactical low level strike aircraft? Perhaps to know that it is there, would be of some psychological value to the crew, even if it is never used!

A projected VTOL military transport which could be used to supply strike aircraft units, with two BE.53 engines in pods for thrust vector control and four specialized lift engines in the fuselage. The aircraft could take off vertically with a payload of 10,000 lb.

We now turn to one of the special aspects of the V/STOL aircraft, notably the base from which it is operated. This may be a short length of road, a rocky outcrop on a mountain side, a forest clearing or a patch of grass or heath land. If the surface is loose it must be protected from jet blast, and practical operating experience is needed to determine the minimum acceptable cover. This is important since if the strike force is to retain mobility its bases must be supplied by air in many cases. This raises the question of the weight of fuel and armament which must be supplied daily to the dispersed site. Suppose there are three aircraft per site completing three sorties each per day and consuming, say for a small aircraft, a modest two tons of fuel per sortie and disposing of one ton of armament each time. Thus $3 \times 3 \times 3 = 27$ tons per day per site. Perhaps the fuel can be supplied by the army, but if not then a major new logistic problem exists for the (probably) short period of intensive operations. (A job for the Breguet 941 or the Westland *Westminster*.) Supply is not the only new problem. On-site storage and camouflage must be arranged for a considerable bulk of material. Other problems spring to mind. In a very fluid war Fifth Columns and infiltrators flourish, and besides maintaining, refuelling and rearming their charges, the ground crew may have to defend their perimeter. Since large numbers of ground crew will be impossible if mobility is not to suffer, it follows that the aircraft must be as simple and quick to service and replenish as it is possible to make it.

The problem of operating V/STOL strike and reconnaissance aircraft in such a way that the ground organization does not limit the aircraft's flexibility has been merely touched upon. One is struck by many similarities to the agricultural aircraft. It is only necessary to increase speed and range and replace the top dressing with explosive, and the duties are very similar! Perhaps the main lesson which stands out above all others is the need to keep the aircraft small and simple. If it is small it presents a difficult target and a small radar reflective area, its fuel requirements are correspondingly reduced and with them the logistic and ground equipment problems at base. If it is simple it will remain serviceable, and fewer valuable specialists will be sleeping rough around the battle field. If it is small and simple the taxpayer will be able to afford it!

Once successful prototypes have been demonstrated, the next big step in the development of tactical V/STOL aircraft will be to get two or three squadrons equipped at the earliest possible date and operating under representative conditions so that some of the multitude of new problems can be tackled and solved.

We at Hawkers believe that the engineering solutions are in sight and will provide an acceptably simple answer to the problems outlined above. Our close work with Bristol Siddeley Engines has been described in part by Dr. Hooker in his lecture before the Institution of Mechanical Engineers last December entitled "The Future of Air Breathing Engines in Aviation."* We believe that at present the Western world is in the lead in the jet V/STOL field, but we are not unchallenged, and if we do not press our advantage it could easily pass elsewhere.

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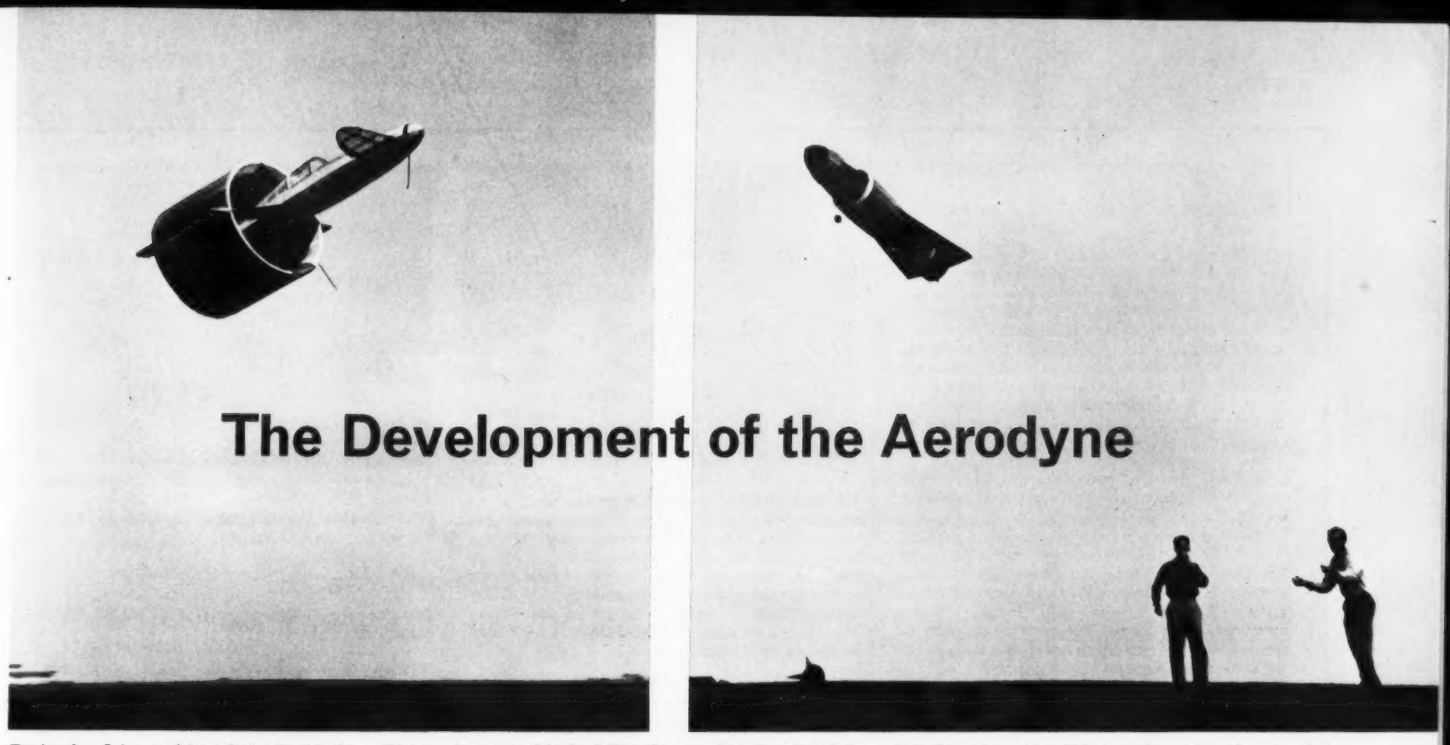
In so short an article it is impossible to cover evenly all the problems of great interest implicit in the title. No doubt many solutions will emerge, and a few will survive. The writer wishes to make it clear that the opinions expressed are his own and do not necessarily represent those of Hawker Aircraft Limited. ←←

* Brief extracts from this paper were published in *Interavia* No. 1, 1960, p. 97.



The Development of the Aerodyne

Testing free-flying models at Cedar Rapids, Iowa. Pictures show a model of a fully stable annular-wing aircraft (canard configuration with tailplane at the nose) and an aerodyne model with jet deflection cascade and conventional tail unit.

By Dr. Alexander M. Lippisch,
Cedar Rapids, Iowa

When the writer of these lines introduced his first delta-wing aircraft to the public thirty years ago, his main intention was to demonstrate the feasibility of Hugo Junkers' "flying wing" concept. We were, however, forced to admit that aircraft designers in those days were not ready for such a major breakthrough in development. In the meantime aircraft development has progressed so rapidly, thanks to the ever greater strides made by the engine manufacturers, that the idea of the "flying wing," born in the days of moderate cruising speeds, has lost its applicability. On the other hand, the delta configuration has proved suitable for high-speed flight.

*

Today, aircraft designers on the look-out for new ideas should again start from a basic concept *which will be applicable for long years to come.* The configuration which evolved out of the powered "glider" many decades ago has reached the end of its useful life. And since the jet airliner is fundamentally only the "stepchild" of military aviation, we should not be surprised to find that many important factors were ignored in its development.

Only those who had a share in the wartime development of the jet aircraft know how many makeshift solutions had to be adopted. That such a pell-mell race left no time for calm consideration and long-term planning is self-evident. It was not possible to make any thorough investigations of the interaction of engine and airframe; there were already enough difficulties involved in changing from the straight wing to the swept wing. Basically, however, everything remained as it was before: the "glider," now fitted with swept wings, was driven by a stream of hot exhaust from the engine itself, instead of the propeller slipstream. The fact that the jet turbine has a very different thrust characteristic from the propeller engine was virtually disregarded.

This was a grave sin of omission—for the engine is and will always remain the core of any aircraft design. When establishing principles for future aircraft designs we must start from the present state of engine development and the progress to be expected in the immediate future. The considerations which led me to make studies of VTOL aircraft a few years ago have been set forth in an earlier article (The Aerodyne Concept, *Interavia,* No. 1/1958). It will therefore be sufficient to give a recapitulation of the main points of the article.

1. An aerodyne should be able to take off and land at zero forward speed.
2. Its cruising speed should be in the high subsonic or supersonic range.
3. The powerplant must consist of several engines, so that the flight may be continued in safety even when one of the engines breaks down.
4. Attitudes on take-off and landing should correspond to those of conventional aircraft.
5. All designs should aim at economy of operation at supersonic speeds; here the achievement of minimum drag depends on ensuring stability and control by means of electronically regulated jets.

These considerations led of necessity to a wingless vehicle generating lift and forward propulsion by an internal flow process. The comprehensive research and development work necessary for such a revolutionary design could, of course, not be completed in a few years. It would be necessary to make a systematic investigation of all the problems associated with jet-supported flight, such as hovering, transition to forward flight, cruising at subsonic speed etc. Here it can be remarked that stability is particularly difficult to achieve in hovering and low speed flight.

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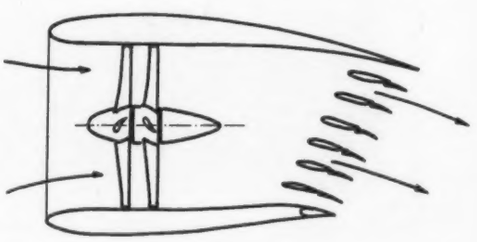
Experiments have demonstrated that the shrouded propeller, or, in more general terms, the ducted fan with vertical axis, is the most effective device for hovering flight. The ducted propeller requires only about *half* the diameter of



The principle of an aerodyne: shrouded contra-rotating propellers; cascade for controllable deflection of the propeller stream.

Aerodynamic Principles

In *diagram I* a given air mass (m_1) is drawn through a hypothetical vehicle by a fan system and ejected rearwards and downwards. In the course of this process this "internal" air mass is deflected about the angle γ and streams out behind the vehicle at a speed v_1; the air immediately around the propulsive stream must follow the direction of the air mass ejected by the fan system. The effect of the internal stream diminishes as its distance from the vehicle increases, and finally disappears altogether.

Our knowledge of the flow induced by the jet stream is at present limited to a few basic principles. It is particularly difficult to arrive at an accurate theoretical conception, as the jet ejected by the internal propulsion process has a substantially higher energy level than the surrounding air. For general purposes we can assume that the forces induced by the external flow are generated by a limited "*virtual*" *mass* (m_0), which directly surrounds the internal flow and undergoes the same downward deflection about the angle γ. As the same static pressure exists both in front of and behind the vehicle, the generated forces can be deduced from the change in momentum of the mass flow per second.

If, for example:

$m_0 = \varrho\, S_0\, v_0 =$
virtual external air mass per second

$m_1 = \varrho\, S_1\, v_1 =$
mass of propulsive stream per second

v_0 = flight speed

v_1 = discharge speed of propulsive stream

γ = angle of deflection of propulsive stream with respect to the horizontal

we can express *lift* by the following equation:

$$L = (m_1 v_1 + m_0 v_0) \sin\gamma \qquad (1)$$

The sum of all horizontal forces, i. e. the *total drag*, is expressed by:

$$D = m_1 (v_0 - v_1 \cos\gamma) + m_0 v_0 (1 - \cos\gamma) + D_{par} \qquad (2)$$

where D_{par} indicates parasitic drag. Finally, the *net power* expended on the generation of the internal propulsive stream is equal to the change in the kinetic energy of the propelled air mass per unit of time, i. e.,

$$P = \frac{m_1}{2}(v_1^2 - v_0^2) \qquad (3)$$

In steady horizontal flight the sum of all horizontal forces will be nil. We can therefore write:

$$m_1 (v_1 - v_0) = (m_1 v_1 + m_0 v_0)(1 - \cos\gamma) + D_{par} \qquad (2a)$$

If, with the aid of equation (1), we substitute for $(m_1 v_1 + m_0 v_0)$ and adopt the functions of the half angles, we have

$$m_1 (v_1 - v_0) = L \tan\frac{\gamma}{2} + D_{par} \qquad (4)$$

In addition, we can write:

$$m_1 (v_1 - v_0) = \frac{2P}{v_1 + v_0} \qquad (3a)$$

$$P \frac{2 v_0}{v_1 + v_0} = (L \tan\frac{\gamma}{2} + D_{par})\, v_0 \qquad (5)$$

Here the first expression in brackets equals the induced drag (D_i) while the fraction following P represents the propulsion efficiency η_{id} of the jet. It is therefore possible to write (5) in the following form:

$$P \cdot \eta_{id} = (D_i + D_{par})\, v_0 \qquad (5a)$$

The actual power required is greater than P, as account must also be taken of the internal efficiency (figure of merit of the power plant). Bearing in mind that the angle of deflection γ is always small in horizontal flight, we can substitute the radian for the sine and the expression $(1 - \cos\gamma)$ approximately by half the square of the radian. We thus have a similar equation to that applicable to the aircraft with wings:

$$m_1 (v_1 - v_0) = \frac{L^2}{2 (m_1 v_1 + m_0 v_0)} + D_{par} \qquad (6)$$

Here the most important fact is that the basic lift/drag relationship corresponds to the normal aerodynamic formulae for the winged aircraft. This relationship can be used to obtain a non-dimensional representation of aerodynamic equations.

For this purpose we shall divide the forces by the expression $\left(\frac{\varrho}{2} v_0^2\, S_1\right)$; in order to avoid confusion with the non-dimensional coefficients of winged aircraft, we shall call the lift coefficient K_L and the drag coefficient K_D. Similarly, we shall establish a power coefficient K_P by dividing by $\left(\frac{\varrho}{2} v_0^3 S_1\right)$. Thus we have:

$$K_L = 2 \sin\gamma \left[\left(\frac{v_1}{v_0}\right)^2 + \frac{S_0}{S_1}\right]$$

$$K_D = 2 \frac{v_1}{v_0}\left(1 - \frac{v_1}{v_0}\cos\gamma\right) + 2 \frac{S_0}{S_1}(1 - \cos\gamma) + K_{Dpar}$$

$$K_P = \frac{v_1}{v_0}\left[\left(\frac{v_1}{v_0}\right)^2 - 1\right]$$

Here K_{Dpar} represents the parasitic drag coefficient, and S_0 is the cross section area of the external virtual air mass measured at the same point as S_1.

For further simplification we shall replace $\frac{v_1}{v_0}$ by λ and $\frac{S_0}{S_1}$ by Φ.

We thus have the following:

$$K_L = 2 \sin\gamma\, (\lambda^2 + \Phi) \qquad (7)$$

$$K_D = 2\lambda (1 - \lambda \cos\gamma) + 2\Phi (1 - \cos\gamma) + K_{Dpar} \qquad (8)$$

$$K_P = \lambda (\lambda^2 - 1) \qquad (9)$$

Turning again to horizontal flight with small angles of deflection, we have:

$$K_P \frac{2}{1 + \lambda} = \frac{K_L^2}{4 (\lambda^2 + \Phi)} + K_{Dpar} \qquad (10)$$

As the expression on the left can be considered as a drag coefficient, we can write:

$$K_{D0} = \frac{K_L^2}{4 (\lambda^2 + \Phi)} + K_{Dpar} \qquad (11)$$

Equation (11) is analogous to the expression for the winged aircraft polar:

$$C_D = \frac{C_L^2}{\pi A} + C_{D0}$$

The "apparent" aspect ratio A of the wingless vehicle will thus be:

$$A \text{ equivalent} = \frac{4}{\pi}(\lambda^2 + \Phi) \qquad (12)$$

In the hypothetical extreme case of flight without additional external flow and without parasitic drag, λ would be equal to one, and the apparent aspect ratio would be equal to that of the annular wing or autogiro, namely $\frac{4}{\pi}$ or 1.27. Theoretically Φ equals one for a slender body, and since λ also equals roughly one we would have an "apparent" aspect ratio of 2.5, corresponding to that of a high-speed aircraft.

It is also clear that the parasitic drag of an aerodyne must be roughly the same as that of a high-speed winged aircraft. While on the one hand the body dimensions of the wingless vehicle must be greater owing to the space required for the internal flow, it is not subject to parasitic wing drag, which increases sharply at high speeds. Lastly, the wave drag at supersonic speed will be considerably less.

Finally, the relationship between angle of deflection and flight speed is of general interest. Under horizontal flight conditions ($K_D = 0$), we have:

$$\cos\gamma = \frac{\lambda + \Phi + \frac{K_{Dpar}}{2}}{\lambda^2 + \Phi} \qquad (13)$$

In slow flight with fairly large angles of deflection, however, the external air mass will no longer follow the internal flow to the same extent; this will lead us to use smaller values for Φ as λ increases. If, for instance, we let K_{Dpar} equal 0.04, then we get the relationship between the angle of deflection γ and a value proportional to the flight speed $1/\sqrt{K_L}$ (see *diagram II*). It will be seen that the angle of deflection alters considerably even at very low forward speeds.

Diagram I: Flow through and round a hypothetical fan vehicle moving at speed v_0 and ejecting its air mass at speed v_1 at an angle of γ. The dark circle shows the cross section of the propulsive jet behind the body (S_1), the lighter area (S_0) the cross section of the "virtual" mass.

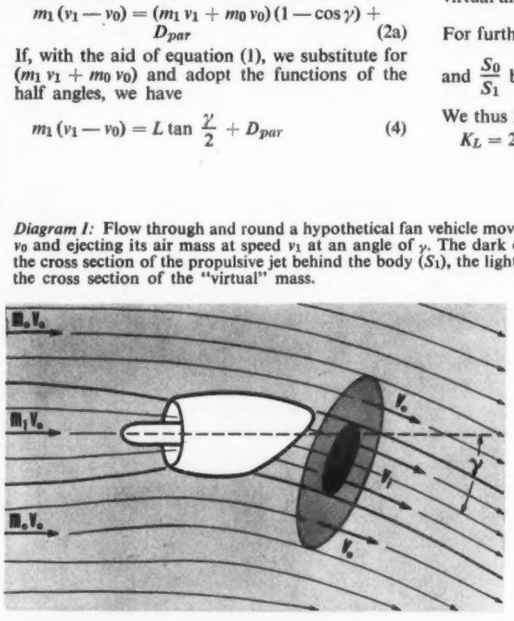
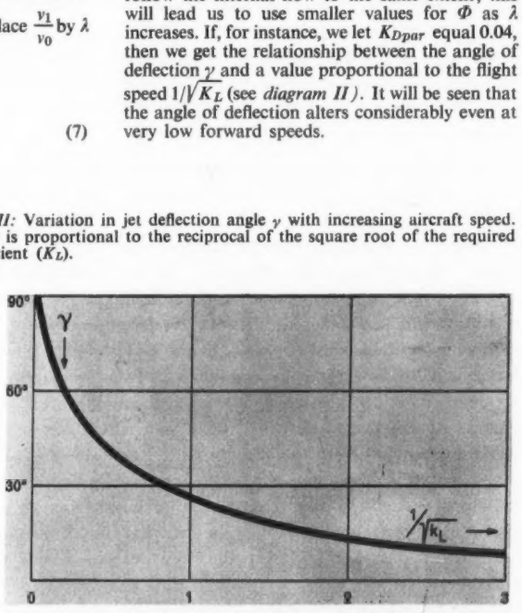
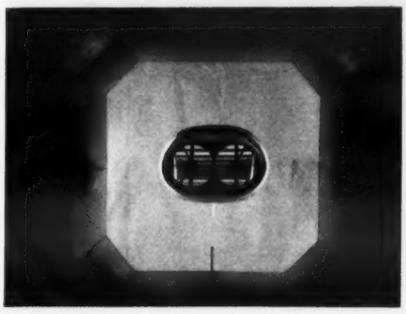
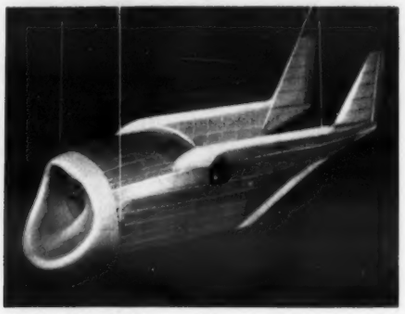


Diagram II: Variation in jet deflection angle γ with increasing aircraft speed. The latter is proportional to the reciprocal of the square root of the required lift coefficient (K_L).





Mark IIIB *in the wind tunnel.*



Mark IIIC *model.*

Recent Measurements on Three Aerodyne Models

Diagrams I and II illustrate the effects of different external shapes on the aerodynamic characteristics of an aerodyne test model. The three different stages of the design can be seen from the drawings below.

In the *Mark IIIA* version the body above and behind the exit of the jet stream blocked the external flow. For this reason it was replaced in the *Mark IIIB* by a slender tail boom; in this way the blocking effect was to a great extent eliminated. Observations of the flow nevertheless showed that two large "tip vortices" were generated at the sides of the outlet. To avoid this, a twin fuselage configuration was adopted for the *Mark IIIC;* this utilized the inflow of the external air towards the jet stream to generate additional lift.

The measurements were made in a small subsonic wind tunnel. In *Diagram I* the lift coefficient K_L will be seen as a function of the angle of attack of the propeller axis; the advantage gained from the above-mentioned improvements is clearly evident. All measurements were taken with the cascade, which can be opened for hovering flight, in the retracted position. *Diagram II* shows the lift coefficient K_L as a function of power or, more precisely speaking, as a function of the value K_{Ptd}, which is proportional to the power input. Here, too, the improvement of the lift at constant power is clearly demonstrated. All models were built so that they could also be used for tests in captive flight. Development was discontinued, however, for financial reasons.

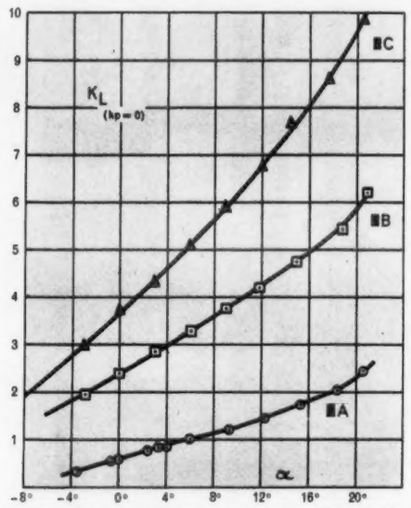


Diagram I: *Lift coefficient as a function of the angle of attack of the propeller axis.*

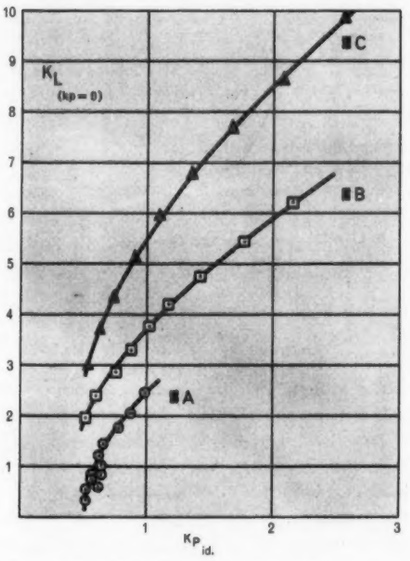
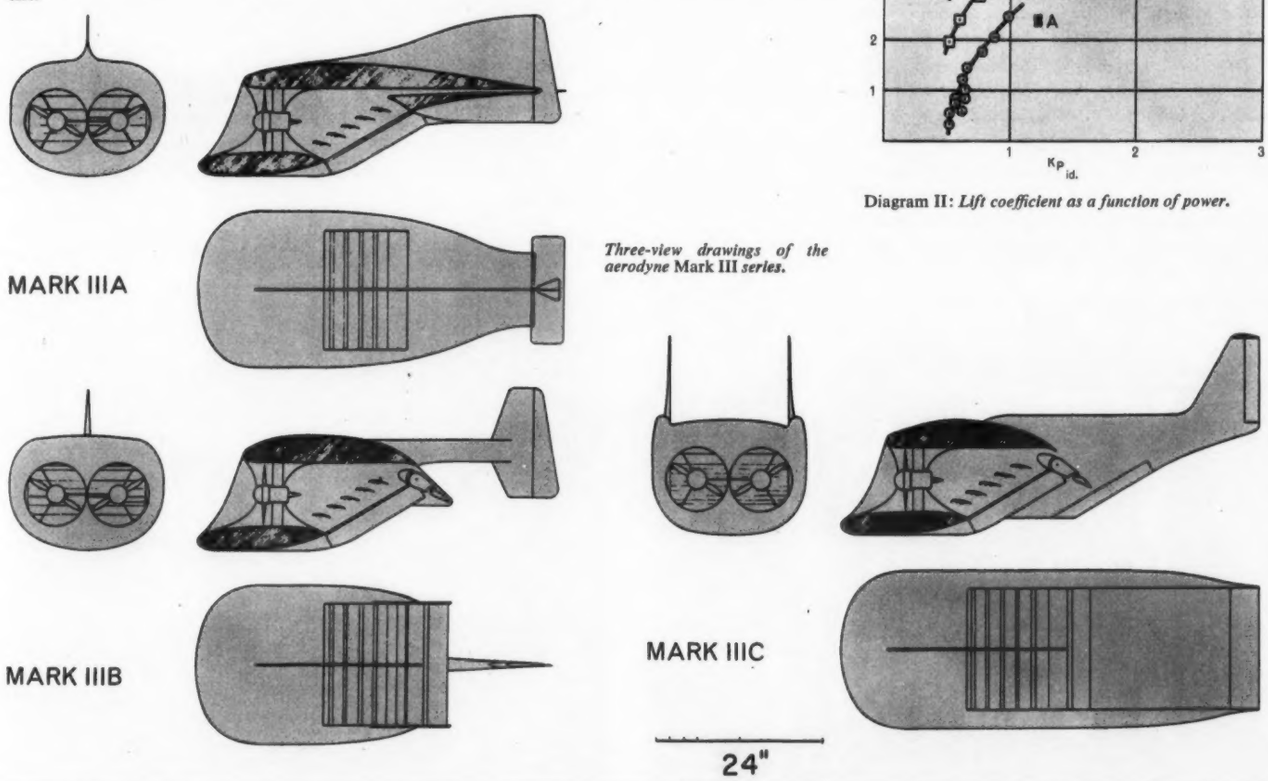
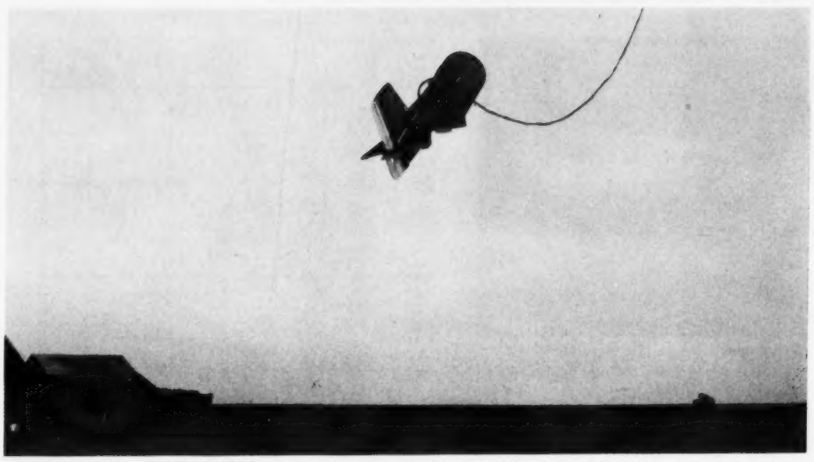
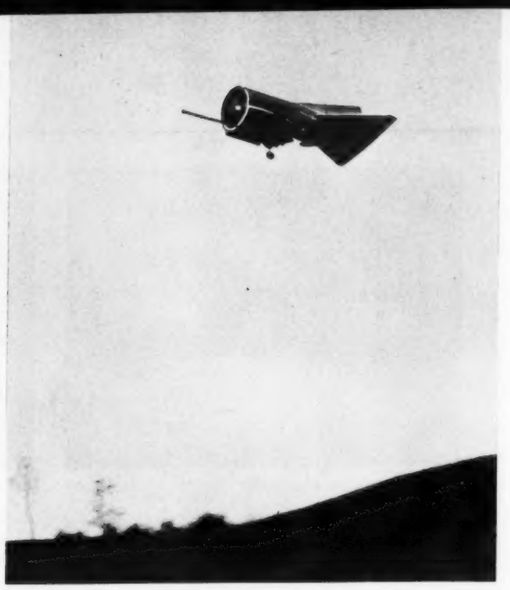


Diagram II: *Lift coefficient as a function of power.*



Three-view drawings of the aerodyne Mark III *series.*





Free flight tests of two models of the "test bed" configuration, left with electrical propulsion for the shrouded propellers (note the cable supplying the electric current), and right with small gasoline engines. Stability and controllability proved to be satisfactory in both cases.

an unshrouded propeller to produce the same performance and thrust. Admittedly, allowance must be made for the additional weight of the ducting, which substantially offsets the power gained. What is more, the stabilizers and control devices for forward flight present serious problems and add a considerable penalty in performance.

It is therefore better to choose *a layout with a practically horizontal intake*, in which a jet directed backwards and downwards can be controlled over a wide angle of attack range by means of a cascade (see diagram). This results in three major advantages:

1. Economy in cruising flight.
2. Stability in forward flight over a wide speed range.
3. Possibility of using the fan duct as a functional element, adapting its external shape to the flow conditions during cruise.

This basic principle can be applied to meet special requirements for the most varied purposes. As, however, there persists the widespread belief that a wingless vehicle lifted into the air by an internal jet stream is governed by different aerodynamic laws than a normal winged aircraft, some of the calculations on which an aerodyne is based are given in the accompanying box; here it will be seen that the basic equations for lift and forward propulsion with ducted fan are comparable with those applicable to winged aircraft.

The aerodynamic principles set out in the box are fundamental to the design of wingless vehicles. As cruising accounts for most of the total flying time, the optimum configuration must be chosen for this flight condition. The best solution to the problem is therefore deflection of the jet over a wide range of angles by means of a cascade. Although the total degree of efficiency is lower in the hovering condition than in cruising flight, this loss is relatively unimportant as take-off and landing are effected in a very short time.

The following simple statement of the relationship between maximum speed and power/weight ratio clearly shows the advantages of the wingless vehicle with respect to the winged aeroplane. The maximum speed attainable can be stated as follows:

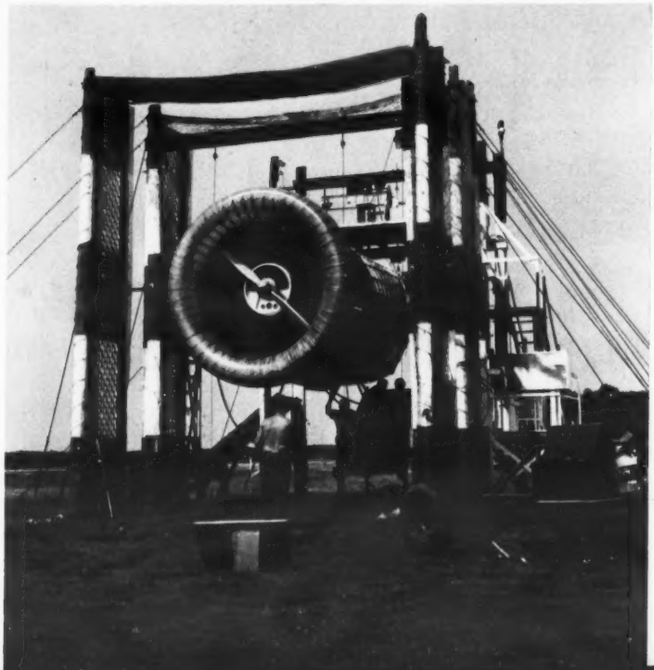
$$v_{max} = \sqrt[3]{\frac{P \cdot \eta}{K_{D0} \cdot S_1 \cdot \frac{\varrho}{2}}} \sim \sqrt[3]{\frac{P}{S_1}}$$

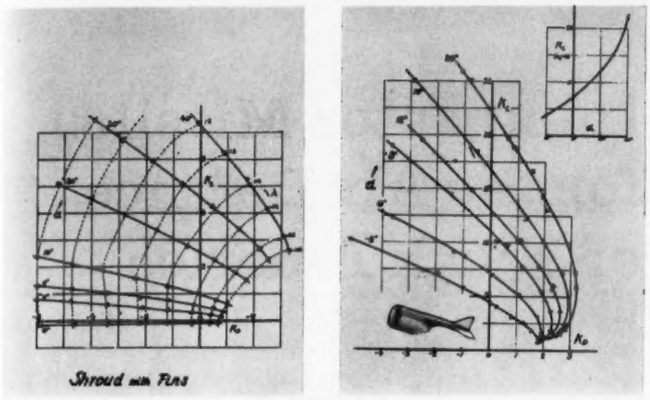
As it is possible to deduce from the hovering condition that the cube root of power over lifting stream cross section area is proportional to the power/weight ratio, we have the following:

$$v_{max} \sim \frac{\text{power}}{\text{weight}}$$

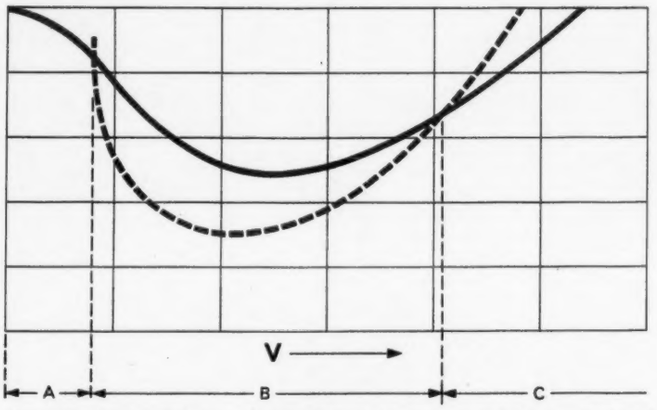
Put differently, this means that the maximum attainable speed of an aerodyne is directly proportional to the power/weight ratio in horsepower per pound, whereas in the winged aeroplane, whose minimum speed is a function of wing loading, maximum speed is proportional to the cube root of the power/weight ratio. Above a certain speed level, therefore, a wingless vehicle will reach higher speeds than a winged aircraft with the same power/weight ratio.

Larger versions of the test bed, now being tested in a NASA wind tunnel. The two-blade propellers of this shrouded blower with deflection cascade have a diameter of roughly 7.5 ft and are driven by two 260 h.p. Lycoming engines; length approx. 42.6 ft, height approx. 14 ft, probable gross weight approx. 2,600 lb.

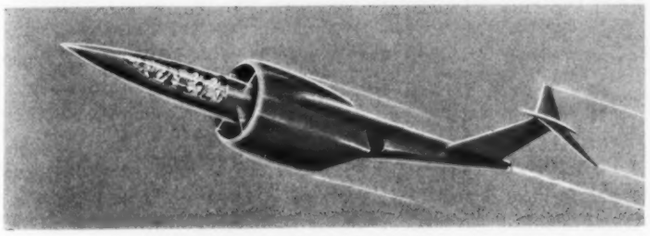


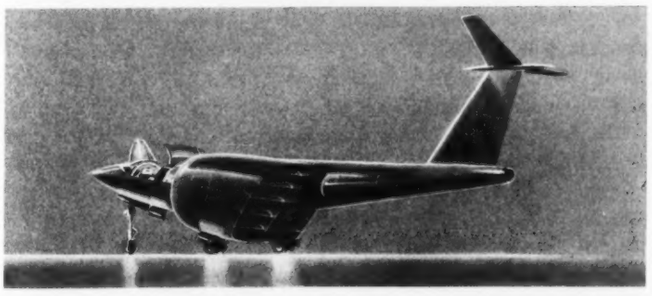


Some results of wind tunnel tests on simple shrouded fans with fins and on an aerodyne test bed model with deflectors set at 40 degrees. Shown here are the non-dimensional lift coefficients (K_L) and drag coefficients (K_D) as a function of angle of incidence of the blower axis (α) and of parameter λ, the ratio of the exhaust velocity of the propulsive jet to the speed of flow inside the tunnel. Measurements were made at subsonic speed.



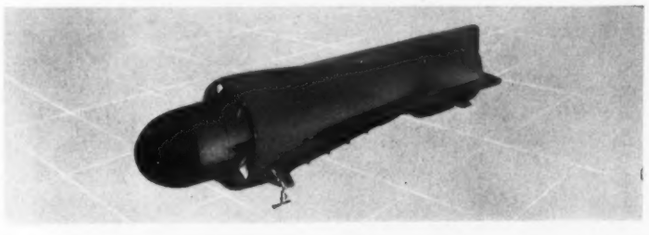
Power requirements for the aerodyne (unbroken line) and a modern high-speed aircraft with wings (broken line) plotted against aircraft speed V. Below a certain minimum speed (area A) every winged aircraft ceases to be airborne, whereas the aerodyne is still capable of hovering at zero forward speed and can therefore take off and land vertically. Between the minimum speed for winged aircraft and speeds of around 400 knots (area B) the winged aircraft requires less power than the aerodyne. Above 400 knots (area C), however, the aerodyne's power requirement is lower, since it needs less wetted area and produces less shock drag in supersonic flight.

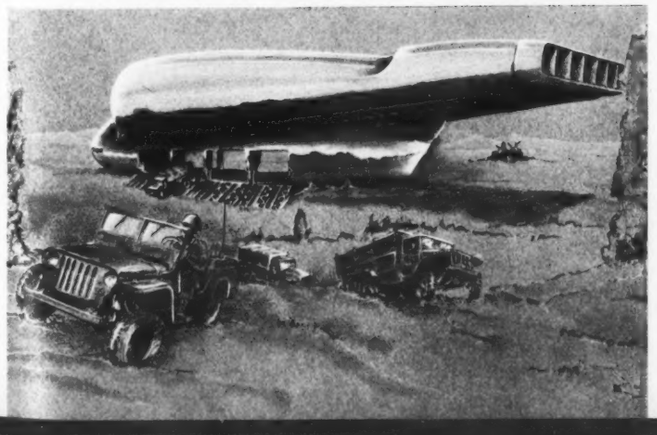




Civil future? Drawing of a VTOL touring aircraft for 6 to 8 persons in supersonic flight (above) and after vertical landing (below).

Military future? Design sketches for a remote-controlled missile with interchangeable head based on the aerodyne formula (above) and a giant transport for the ground forces.





The disadvantage of the aerodyne, which is perceptible at moderate cruising speeds in the subsonic range, disappears as speeds become higher, and finally turns to an advantage. While the minimum wing size of an aeroplane is always limited owing to the requirement for a given minimum speed, the aerodyne is not subject to such restrictions, even though it must fly at zero forward speed. In order to achieve small size (low drag) and low structural weight, the maximum power per weight unit is essential; this greatly increases the economical cruising speed.

Of decisive importance in the design of aerodynes is thus the specific weight of the engine. With a conventional piston engine it would be practically impossible to keep the installed weight within tolerable limits, owing to the large mass flow capacity required. On the other hand, modern gas turbines—with specific power/weight ratios of 2.5 to 4.5 h.p./lb—can be made small enough to meet structural requirements. A revolutionary configuration such as the aerodyne has, of course, been made possible only by the advanced stage of development of modern aero engines.

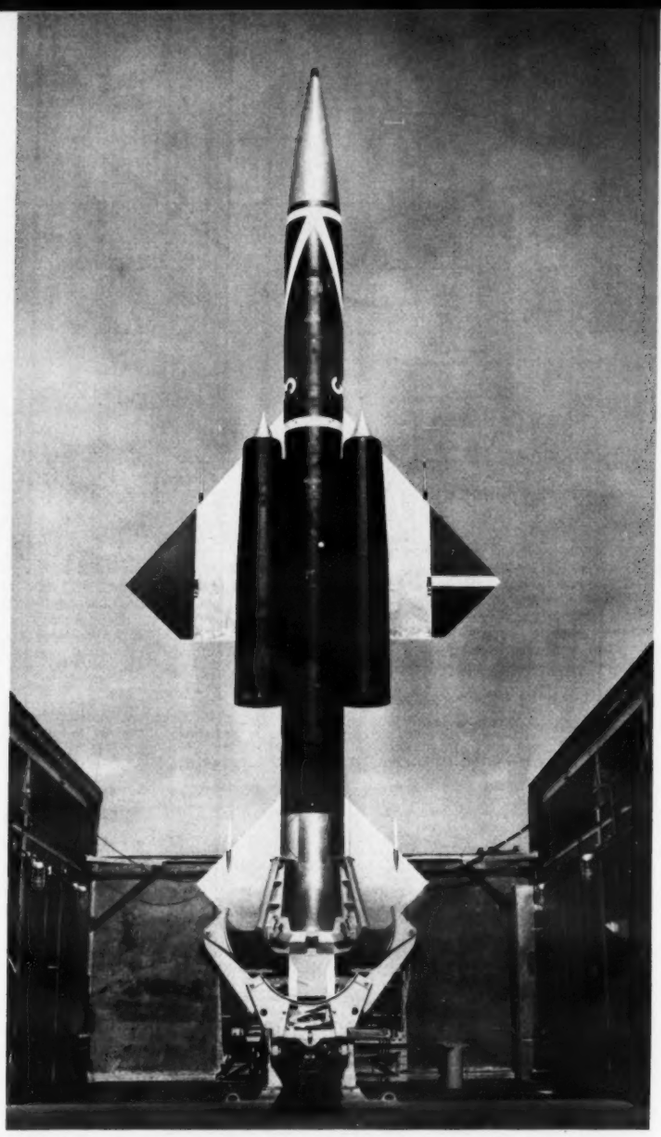
*

A study of the problems of hovering and slow forward flight is essential to a knowledge of the characteristics of the wingless configuration. Particularly important are the questions of stability and controllability, the latter being a decisive factor in manned vehicles.

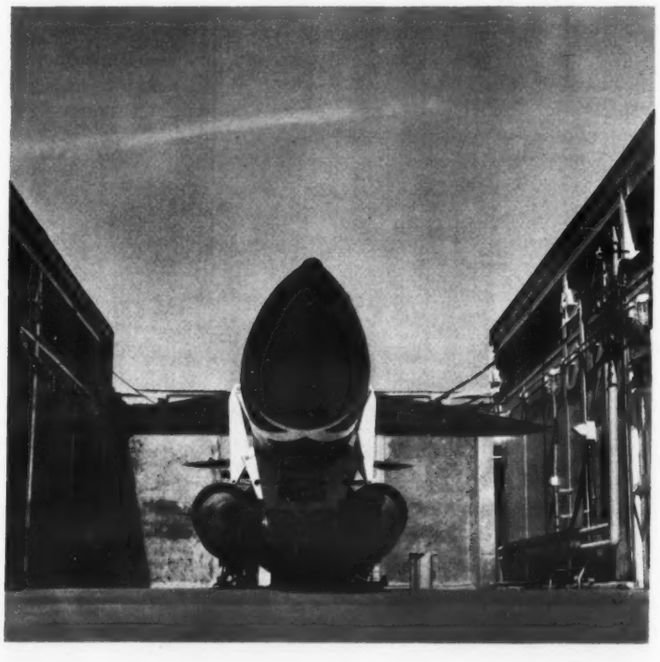
It is, of course, obvious that dynamic stability in the hovering condition cannot be achieved without auxiliary systems; for this purpose a rate gyro can be used. The transition from hovering to forward flight at moderate speeds can be tested either in a wind tunnel or with the aid of remote-controlled electrically powered models.

The results of such preliminary studies led to the testing of a series of models in free flight. Here it was learnt that a wingless vehicle fitted with conventional control surfaces could be pitch stabilized both statically and dynamically. Finally, we built a test bed to study stabilization problems. This is being tested in a large NASA wind tunnel and should supply information on controllability during hovering and transition to forward flight at moderate speed.

A whole series of basic studies is necessary in this field before we can proceed to the construction of vehicles capable of economical cruising flight. Even today, of course, the state of development of turbine engines would enable us to put all kinds of "odd aircraft" into the air, but these would have merely a certain "publicity value"; our basic knowledge is not yet adequate for us to embark on engineering work with any real prospects of success. The failures of hurriedly prepared experimental vehicles all too frequently lead so-called "experts" to draw over-hasty conclusions which stifle promising ideas at birth. There is no lack of discouraging examples of this kind, but we should not allow ourselves to be deterred, since they all provide us with useful lessons. ◆◆



The IM-99B *Bomarc* interceptor missile in the Boeing Aero-Space Division's experimental launching shelter at Seattle. The heavy roof panels of the shelter have been opened, and the missile has been raised to a vertical position by means of the launching cradle (upper picture). After the missile has been erected, the cradle returns to the horizontal position, and the *Bomarc*, supported only by four clamps, stands on its platform ready for launching. The lower picture shows the IM-99B in a horizontal position on its launcher.



V/STOL

Interceptor Missiles for the Air Defence of North America

Since *Interavia* first analysed the Boeing IM-99 *Bomarc* some two years ago, American defence planning in the air defence sector has undergone an unmistakable shift in emphasis. In the face of the rapidly progressing development of intercontinental ballistic missiles and their introduction into operational service, the Pentagon has been obliged to recognize that for the time being there is no effective defence against all threats from the air. As a result, defence against manned long-range bombers was relegated overnight to a secondary position in the overall aerospace defence complex. If—so argued the military experts—the Soviets do have ballistic weapons of intercontinental range, they will not deal the first surprise blow at the United States with subsonic bombers. Thus while the programmes for the Ballistic Missile Early Warning System, the *Midas* and *Samos* reconnaissance and identification satellites and the *Zeus* anti-ICBM missile have been accelerated, the USAF has announced cuts in its procurement programme for the Boeing *Bomarc* air defence robot and the SAGE semi-automatic early warning and data transmission system.

The cuts in the *Bomarc* programme and economies in the SAGE system came as no surprise, since Secretary of Defense Thomas S. Gates had forecast drastic reductions in expenditure for air defence in hearings before the Congress as far back as January. At least $300 million is to be pared from the figure of $445.6 million originally programmed for the *Bomarc* in the 1961 fiscal year. A further $275 million is to be saved by reducing the number of SAGE control centres. For this purpose it is proposed to abandon plans for *Bomarc* units at the following four Air Force Bases: Paine AFB, Washington, Adair AFB, Oregon, Travis AFB, California, and Vandenberg AFB, California. Also abandoned are plans for hardened SAGE Super Combat Centers in the western part of the United States. The cutbacks in the USAF's *Bomarc* programme will not, however, affect either the number or the schedules for the IM-99 squadrons destined for the Royal Canadian Air Force, so that including the two Canadian squadrons in Ontario and Quebec there will still be 14 *Bomarc* units in the North American continent.

One striking fact emerges: the 12 USAF bases and relevant SAGE centres are all concentrated in the north and northeast of the United States. The northwestern flank of the North American continent would therefore remain unprotected, and it looks as if the Pentagon had decided that there is no longer the slightest risk of attacks by manned bombers in this sector. It is, however, clear that if in the event of global war enemy jet bombers should nevertheless penetrate into the United States airspace the task of defending the whole of the North American continent against them would fall to the USAF's manned supersonic fighters and the unmanned *Bomarc* interceptor missile. For some years to come, therefore, this ramjet-powered missile will form one of the main weapons of the U.S.-Canadian defence system. Small wonder that Washington hastily assured Ottawa that the USAF cuts would in no way affect the Canadian *Bomarc* squadrons. Since the Canadian Government decided against production of the Avro CF-105 *Arrow* supersonic fighter a year ago with the argument that the *Bomarc*

formed a fully valid replacement, the latest American budget economies must nevertheless have caused some concern.

*

The following is a brief summary of the IM-99 programme to date: Of the 18 *Bomarc A* squadrons originally requested on the North American continent, only 14 remain—twelve in the north and northeast of the United States and two in Canada. Of the twelve U.S. bases, four are to be fully equipped and operational by June 30th,1960, and another four by the end of the 1961 fiscal year. So far, only weapons of the IM-99A series have been delivered, though version IM-99B is to follow during fiscal 1961; the latest cuts thus affect only the *Bomarc B* model. The total fourteen bases will probably not be fully equipped until 1963. The first base was inaugurated at McGuire AFB, Trenton, New Jersey, in the autumn of 1959. A training centre for all *Bomarc* operators has been set up at Eglin AFB on the island of Santa Rosa, off the coast of Florida. All flight testing so far has been carried out at Cape Canaveral.

The A model of the missile has an Aerojet-General LR59-AG-13 liquid-propellant engine (kerosene and nitric acid) in the fuselage rear and two Marquardt RJ43-MA-3 ramjets beneath the fuselage (operating on 80 octane gasoline). The liquid-propellant engine raises the *Bomarc* vertically from the ground and accelerates it during climb to high subsonic speeds, whereupon the two ramjets take over, carry the missile to the projected cruise altitude and continue to burn (at full thrust) until the target is reached.

On February 23rd, 1959 an agreement was signed in Washington giving Canadair Limited rights to manufacture *Bomarc* wings and wing-tip ailerons under licence from Boeing. The licence programme has since been speeded up; the sub-assemblies built in Canada have in all cases been delivered on schedule. At the same time Boeing concluded an agreement with Canadair Services Ltd., of Montreal, for the latter company to send some 180 scientists and engineers to Boeing so as to advance the development work and the preparations for the introduction of the *Bomarc B* into service. Final assembly of the *Bomarc B*, however, is in the hands of the Boeing plant, which delivers the finished missile to NORAD for operation at Canadian and U.S. bases.

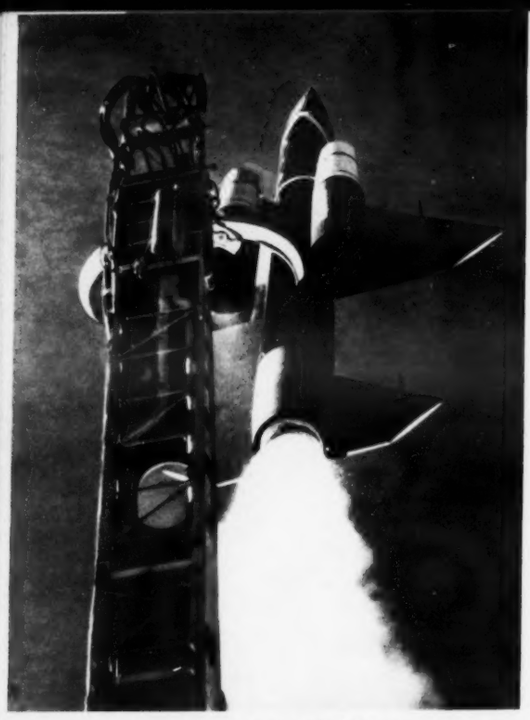
Meanwhile Boeing's Aero-Space Division has already begun production of the IM-99B. The accompanying box gives comparative data for the A and B models and details of the considerably improved performance of the latter. The B version has a Thiokol Chemical Corporation solid-propellant

Production of *Bomarc* wings and ailerons at the Missiles and Systems Division of Canadair Limited, Montreal.

Comparative data for Bomarc A and B

Type designation	IM-99A	IM-99B
Power units	1 Aerojet-General LR 59 liquid-propellant engine of 35,000 lb static thrust 2 Marquardt RJ43-MA-3 ramjets of 23,000 lb max. static thrust	1 Thiokol solid-propellant motor 2 Marquardt RJ43-MA-7 ramjets
Span	18 ft 2 in.	18 ft 2 in.
Length	46 ft 9 in.	45 ft
Span of tailplane	10 ft 6 in.	10 ft 6 in.
Fuselage diameter	35 in.	35 in.
Launching weight	15,000 lb	approx. 16,000 lb
Speed	Mach 2+	Mach 2+
Ceiling	over 60,000 ft	over 70,000 ft
Range	200–250 miles	400+ miles
Warhead	Chemical or nuclear	

Final assembly of the *Bomarc* at Boeing's Missile Production Center in Seattle. With the exception of the nose and tail, the entire airframe, which is built of steel skin panels, serves as a container for the rocket and ramjet propellants. The ridge running along the missile's back (not yet covered in picture) contains cables, wiring and auxiliary equipment.



Launching of a Boeing IM-99B from Cape Canaveral firing range. The solid-propellant motor in the tail accelerates the missile to high subsonic speed; the ramjet engines then take over and carry the missile to its target.

MANTRAC

To enable the IM-99 *Bomarc* weapons system to be used in regions where neither SAGE nor comparable radar and control networks are available, Boeing has developed a procedure known as MANTRAC (Manual Angle Tracking Capability), which works on the simple principle of triangulation, using the compass bearings of the enemy target measured by two radar stations. The picture shows the transparent boards on which the air situation is plotted from information telephoned from the radar stations. To the right and left of the centre board (with grid network) the compass bearings of the air targets detected by the radars are entered on two sliding transparent boards; when these are slid inwards, the point at which the two azimuth lines intersect marks the position of the target. The observer kneeling in the centre then plans the interception action to be taken by the *Bomarc* unit under his command and gives the order for the missiles to be launched.

rocket motor instead of the liquid-propellant engine. The space thus saved inside the fuselage is used to carry a bigger fuel supply for the two ramjets, thus ensuring a longer range. The Marquardt ramjets have also been improved compared with those in the A model and converted to operate on JP-4, which is available at all USAF bases. During flight testing these highly efficient ramjets have operated at altitudes of up to 100,000 ft and speeds corresponding to Mach 4. Finally, the *Bomarc B* has a new Westinghouse autonomous target-seeking radar head, to detect enemy air targets both at low level and very high altitudes. The radar can detect, from an altitude of more than 65,000 ft, an enemy flying low over the ground at some 50 ft. While the A version has a range of 200 to 250 miles and can protect an area of 196,000 square miles, the B version's range is 500 miles and the area protected 500,000 square miles.

The McGuire *Bomarc* base (shown here in course of construction) was completed and transferred to the USAF in September 1959. The picture shows the 28 launching shelters, connected with the base control station and the nearest SAGE centre by a complex system of lines and cables.

Both versions of the *Bomarc* are radio guided to the immediate vicinity of the target, with the signals being transmitted by a computer in the SAGE system on the basis of information processed from all radar stations in the network. However, to enable the *Bomarc* weapons system to be operated in areas where there is neither SAGE nor a comparable radar and control system, Boeing's Aero-Space Division has developed a system known as MANTRAC (Manual Angle Tracking Capability) which works on the triangulation principle, i. e., by measuring the angle between the air target and two known ground points (position of search radars). Each radar in the defence area is connected by telephone to the MANTRAC centre and transmits the compass bearing of attacking aircraft to the centre, where details are marked manually on a transparent plotting board. The *Bomarc* launching controller can then calculate the required initial data for the operation of his unit.

A *Bomarc* squadron normally comprises 28 missiles, each stored in a separate air-conditioned reinforced concrete shelter. All 28 launching sites have their own command line direct to the nearest SAGE control centre, where a simple push-button operation suffices to open the heavy concrete roofs of the shelters. Thereupon the launching rigs are erected, and a control and test system automatically undertakes all launching preparations. The actual launching shelters are thus unmanned and need only be checked occasionally by the inspection teams. Only the final assembly shed, the maintenance shops and the stores depot at a *Bomarc* base are permanently manned. Nevertheless the full ground crew for a base numbers some 275 men.

With fully automatic remote control from a SAGE centre, the *Bomarcs* can be ready for launching within one minute. Theoretically, all 28 missiles at a squadron could be fired in a single second; the SAGE control centre can direct two hundred missiles simultaneously.

Thanks to its great range, the *Bomarc* can be based in isolated regions, far from industrial or residential areas, and the number of bases and missiles required for a given sector can be kept relatively small. The 7-ton IM-99 can intercept enemy air targets at twice the speed and over the same ranges as supersonic fighters of twice its weight. Moreover, the *Bomarc* is not only an unmanned interceptor, but also a VTO machine which—though each can be fired only once—has proved its capacities in dozens of test launchings. ←

From Meadow to Jet Runway

Schiphol's Fortieth Anniversary

It looks as if Airport Manager Dellaert was right. A year ago—as air transport entered the jet age—*Interavia's* Netherlands Correspondent asked him the somewhat awkward question whether, in his opinion, Schiphol had any chances of remaining one of Western Europe's leading airports, or whether it did not run the risk of losing intercontinental traffic to the great "inland" airports, such as London, Paris, Frankfurt and Rome.

"It is my firm conviction," replied Dellaert, "that, though there will be a tendency to centralize intercontinental air traffic, Schiphol Airport will remain a base for the fast, large aircraft of the future, even if another revolutionary development in aircraft design, such as nuclear propulsion, leads to intercontinental operations with still larger aircraft..."

As if in confirmation of these words comes the recently published Schiphol annual report for 1959; for last year the number of passengers handled passed the million mark for the first time.

Schiphol Traffic Volume

	1959	1958	Increase
Passengers	1,134,787	972,510	+ 17%
Freight (tonnes)	38,723	30,882	+ 25%
Mail (tonnes)	4,398	3,504	+ 25%
Baggage (tonnes)	21,664	18,532	+ 17%

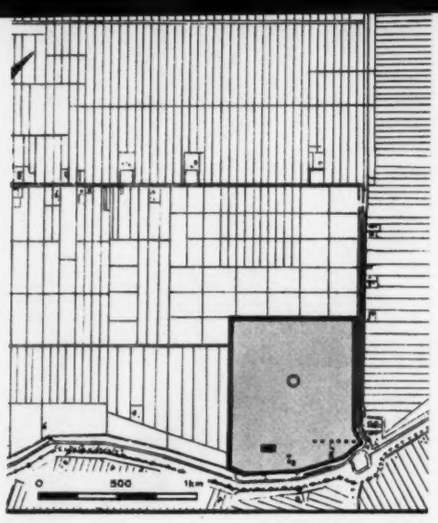
Although the number of passengers handled at the Dutch airport is less than those at other European centres, such as Paris (2,973,676), Frankfurt (1,603,851) and above all London (1959 figures not yet published), the 17 percent increase speaks for itself (Paris + 11 percent, Frankfurt + 14.2 percent).

Dellaert's confident forecast was based on the central position of Schiphol in the most densely populated part of Western Europe, the proximity of West Germany with its rapid economic growth and consequent increase in demand for air transport and, finally, the fact that Schiphol is the operating base of KLM, whose strong position among the world's airlines is a fact not to be overlooked.

The history of Schiphol Airport is marked throughout by close collaboration with the Dutch national carrier, for it was from here that, on May 17th, 1920, KLM's first aircraft —a de Havilland DH.16 chartered from the British company Air Transport and Travel Ltd.—took off with two passengers and a bundle of newspapers on its first scheduled flight between Amsterdam and London. Schiphol was the starting point for a daring long-range venture in June, 1927, when a KLM Fokker F-VII made the trip to Batavia (now Djakarta) in ten days; Schiphol was the first European airport to shelter a Douglas DC-2 in its hangars; and Schiphol was the scene of KLM's rapid recovery after the second World War.

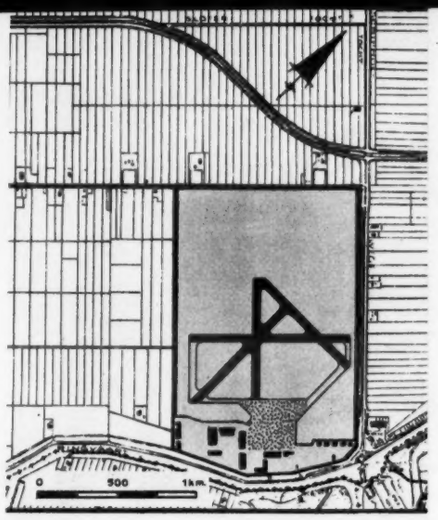
But the association with KLM was not the only factor of decisive importance for Holland's national airport. Parallel with the story

May, 1920: KLM's first "airliner," a chartered de Havilland DH.16, arrives at Schiphol from London with two passengers and a bundle of newspapers. Far right (with bowler hat and stick): Albert Plesman, the young founder and Manager of KLM. **1945:** Reconstructing Schiphol Airport, which was totally destroyed during World War II.



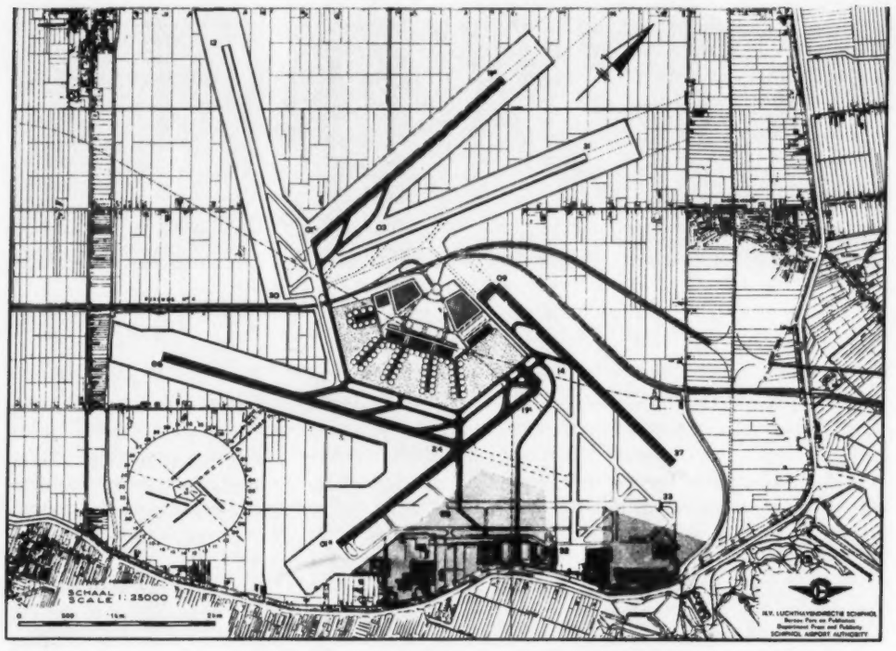
1920

Schiphol Airport consisted of a 190-acre meadow and a few disused Air Force hangars.



1938

The airport covered an area of 520 acres and had four runways, the longest of which measured 3,346 ft.



1960

The extension project calls for four 10,830-ft runways grouped around the airport buildings in the centre. The first runway will be placed in service on April 14th; the second has already been lengthened to 8,360 ft; and construction work on the third is scheduled to begin in 1961.

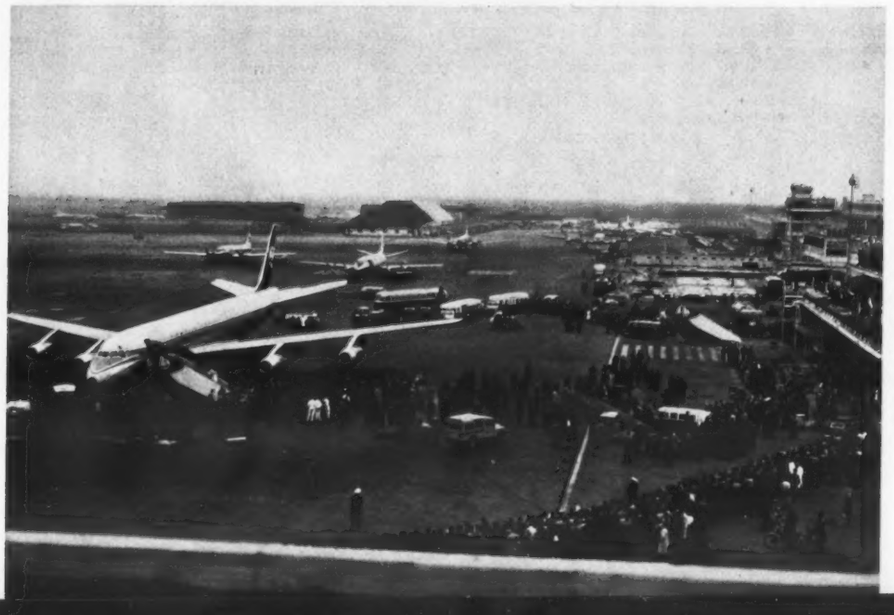
of Schiphol runs that of the man who, in 1920, put up the first hangars in the meadow on the "Ringvaart," who has served Schiphol for forty years with an amazing singleness of purpose and who will preside at his airport's jubilee celebrations on May 17th, 1960: U.F.M. "Jan" Dellaert, Europe's first airport manager.

Quite understandably, the history of aviation gives such prominence to the names of great pilots and inspired designers that the pioneers of ground organization are relegated to almost total oblivion. But it is precisely now, when airport problems are becoming ever more pressing, that we should remember those men whose work has enabled us to profit from the designer's achievements and the pilot's skill.

Dellaert, a Flemish farmer's son from Westdorpe, in the province of Zeeland, came into contact with aviation and the needs of ground organization for the first time in 1916, when he was a lieutenant commanding a coastal artillery battery at Flushing; he was stationed near an Air Force unit whose airfield was so small that practically every landing was an emergency landing. Dellaert had himself transferred to the Air Force, entered the training centre at Soesterberg, made the acquaintance of Lieutenant Albert Plesman... and anyone familiar with the name of Albert Plesman can work out the rest for himself. Scarcely had Dellaert returned to civilian life after the end of the war, when he received a telegram from Plesman offering him the post of "station manager" in the newly founded KLM. At the same time the Netherlands Ministry of Public Works appointed him the first State Airport Manager.

When Dellaert arrived at Schiphol on June 15th, 1920, he found an extensive area of grass and a disused military hangar measuring 65×82 feet. The engine section consisted of a square chalked on the floor, on which were scrawled the words: "This is the engine section." Writ large on the walls was Albert Plesman's motto: "The engine is the soul of the aircraft."

The first of the twelve Douglas DC-8 airliners ordered by KLM arrives at Schiphol.



Schiphol Airport Restaurant.

The airport staff consisted of six men: Dellaert, his deputy, two RAF mechanics, a secretary and a chauffeur, who drove the passengers to and from the airport in an open Army surplus Packard and ran a one-man canteen. In the early days there was no paved way from the hangar to the aircraft, so that in wet weather the passengers had to be carried through the mud to the aircraft by two strong men. The effect was the more picturesque as KLM passengers were then provided with leather coats, helmets, goggles and hot water bottles. Each time an aircraft landed from England a customs official had to race over to Schiphol from Amsterdam—and when winter set in the hangar door was locked.

U. F. M. "Jan" Dellaert, Manager of Amsterdam-Schiphol Airport since June, 1920.

But it was not long before Dellaert made his airport habitable. In mid-1921 the first airport restaurant was opened. Schiphol rose rapidly to the position of one of the most active airports in Europe: an Amsterdam–Brussels service was inaugurated in 1922; Amsterdam–Paris 1923; Amsterdam–Copenhagen 1925; Amsterdam–Basle 1927.

When, in April, 1926, Schiphol passed into the hands of the city of Amsterdam, and Dellaert left the service of KLM for that of the municipality, Albert Plesman wrote: "The safety and regularity of KLM services, our excellent relationships with passengers and authorities, are largely the result of your work... I heartily congratulate you on this new job and I hope that under your leadership Schiphol may become one of the world's foremost airports..."

Dellaert has not disappointed these hopes. In 1938 Schiphol recorded a total 112,546 passengers; and twenty-one years later, no fewer than 135,035 passengers were handled in a single month, September, 1959.

During the occupation of the Netherlands in World War II Dellaert sat on four "underground" technical committees which studied future plans for Schiphol. And in September, 1944, days after the occupation forces had blown up the installations at Schiphol, Dellaert was to be seen wandering across what had once been the airport, picking pieces of wood from among the débris and—who knows?—taking the measures of the new terminal building.

*

The stages of post-war development can be summed up in a few words: The passenger volume has risen in the past decade from 383,399 to 1,134,787. In respect of freight handled, Schiphol takes third place among European airports (this is largely due to the consignments of flowers despatched from Aalsmeer flower market and to transport contracts from shipping companies). In 1958 London, Paris and Amsterdam recorded the following freight volumes (in tonnes): 57,441; 44,508; 30,882. Scheduled services to Schiphol are run by KLM and 19 foreign airlines* which will be joined by Alitalia and Olympic in 1960. Of these companies, the following operate jet airliners: Pan Am (Boeing 707), KLM (Douglas DC-8), Aeroflot (Tu-104A), Finnair (Sud-Aviation *Caravelles* from April 18th onwards), SAS (*Caravelles* from April 25th onwards).

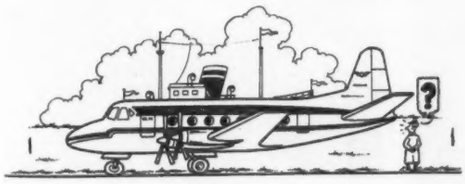
The first DC-8 is handed over to KLM. Left to right: Donald W. Douglas, KLM President General I. A. Aler, Flight Captain R. Van den Homert (KLM).

Financially, like most other European airports, Schiphol is running at a loss. In 1958 the deficit was kept within reasonable bounds —45,000 guilders (U.S. $11,840)—although the Indonesian Government's withdrawal of Netherlands landing rights in 1957 had a damaging effect. In coming years, however, the airport administration expects the deficit to be somewhat higher, as the jet expansion programme, begun two years ago, requires considerable financial resources. A total of four 10,830-ft runways is planned. One runway, whose present length is 8,360 ft, was completed some time ago; a second, 10,830ft long and 148 ft wide with 49-ft safety shoulders at each side, was placed in service on April 14th, 1960; and construction work on a third is to start in 1961. A number of other projects are also in hand—extension of the airport apron and terminal building, the taking over and conversion of existing buildings, modernization of the airport lighting system—which are expected to take five or six years. Investments for the whole extension project will be of the order of 200 million guilders (U.S. $52,100,000).

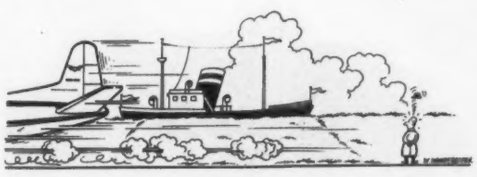
Amsterdam-Schiphol control tower.

But, in spite of these setbacks, Schiphol's state of health leaves no cause for concern. On January 22nd, 1958 it was transferred from the control of the city of Amsterdam to that of a new limited liability company, whose capital is held by the Kingdom of the Netherlands and the municipalities of Rotterdam and Amsterdam. It goes without saying that "Jan" Dellaert was among the "permanent fixtures" taken over by the company; and *Interavia* wishes that he may soon chalk up his second million passengers. ◆◆

* The following companies run regular scheduled services to Schiphol: Aer Lingus, Aeroflot, Air Ceylon, Aramco, BEA, Canadian Pacific, CSA (Czechoslovakia), Finnair, El Al, Icelandair, KLM, LOT (Poland), Malev (Hungary), Pan Am, Sabena, SAS, Silver City, South African Airways, Swissair, Tarom (Rumania).



KLM airliner with funnel and masts? Schiphol Airport is 13 feet below sea level and has to be drained by pumps.



Aviolanda's Woensdrecht repair plant.

Aviolanda's Woensdrecht Repair Plant

One of the oldest Netherlands aircraft factories still taking an active part in aircraft maintenance and production is Aviolanda Maatschappij voor Vliegtuigbouw N. V., at Papendrecht, a small town on the river delta south of Rotterdam. The company was established in 1927 by the late Rotterdam shipbuilder Hendrik A. Burgerhout and early turned to all-metal aircraft manufacture, building a number of Dornier *Wal* flying boats under licence for the Netherlands Naval Air Service stationed in the former Netherlands East Indies. This order was followed by production of a batch of Dornier Do 24K flying boats, also for the overseas units of the Naval Air Service. As time went on, the company added a special repair and maintenance section, to cope with growing commitments for the upkeep of the expanding fleet of naval and land-based aircraft in service both at home and overseas.

After World War II Aviolanda, rebuilt and equipped with modern tooling, continued its activities on a bigger scale. Initially, large numbers of aircraft, including the Fairey *Firefly,* North American *Harvard,* Consolidated *Catalina* and Douglas *Dakota,* were repaired and overhauled for the Netherlands and other air forces. Soon the company was back in the production business, with licence manufacture of Gloster *Meteors* for the Royal Netherlands Air Force, and when these were replaced by Hawker *Hunters* Aviolanda again got a respectable share in the production.

Since 1954 the company has had its own development section, which has designed, for example, a small remote-controlled radio-operated target drone, the AT-21. More recent work includes development of the *Aviobridge,* a hydraulically operated telescoping gangway to enable passengers to walk under cover straight from the terminal building to the aircraft on the apron.

The original plant at Papendrecht, which had been designed for the manufacture of flying boats, had been built on a river and was less suitable for work on large land-based aircraft. It was therefore decided to construct a new facility, known as the Aviolanda Repair Plant, at the edge of Woensdrecht Air Base, in the southwest of the country not far from the Belgian frontier.

On a recent visit to Woensdrecht, *Interavia's* representative in Holland was shown round the plant by Managing Director J. Goedkoop, who devotes a large part of his time to Woensdrecht. The plant today employs some 450 skilled workers in modern, well-equipped workshops. In addition to stores and inspection departments, facilities include radio, electronic, instruments and hydraulic repair shops, a drawing office, main offices and canteens. Broad taxiways connect the hangar with the 8,000-ft runway. Of the total area of roughly 1,033,000 sq. ft., buildings occupy something like 75,000 sq. ft.

During the past few years Aviolanda has specialized in the reskinning of Douglas DC-6 airliners, a process designed to lengthen the aircraft's useful life. Work is carried on in two shifts, and each aircraft runs through the plant in 7 to 8 weeks. Reskinning comprises replacement of the lower fuselage and lower wing skin panels, and includes rebuilding of the wing integral fuel tanks. Aviolanda has so far reskinned ten DC-6s, including six for KLM, two for Alitalia and one each for Sabena and TAI. Two more Sabena DC-6s are expected shortly.

Apart from this work Aviolanda also repairs and overhauls a wide variety of military fixed-wing aircraft and helicopters for the NATO air forces. These include Lockheed T-33 trainers, North American F-86K *Sabres,* Grumman *Avengers,* de Havilland Canada *Beavers,* Piper *Super Cubs,* Lockheed P2V-5 *Neptunes,* Hawker Mk. 6 *Hunters,* Sikorsky H-19, H-34 and S-55, Sud-Aviation *Alouette* and Hiller H-23 helicopters, as well as Beechcraft and de Havilland executive aircraft.

Despite this extensive current activity, Woensdrecht is looking to the future of its labour force. Like the main Papendrecht plant, it runs a training school where some 40 apprentices receive comprehensive theoretical and practical instruction to fit them as skilled aircraft mechanics, electricians, toolmakers or bench workers. ⟷

Reskinning a Douglas DC-6.

In the Woensdrecht inspection shop.

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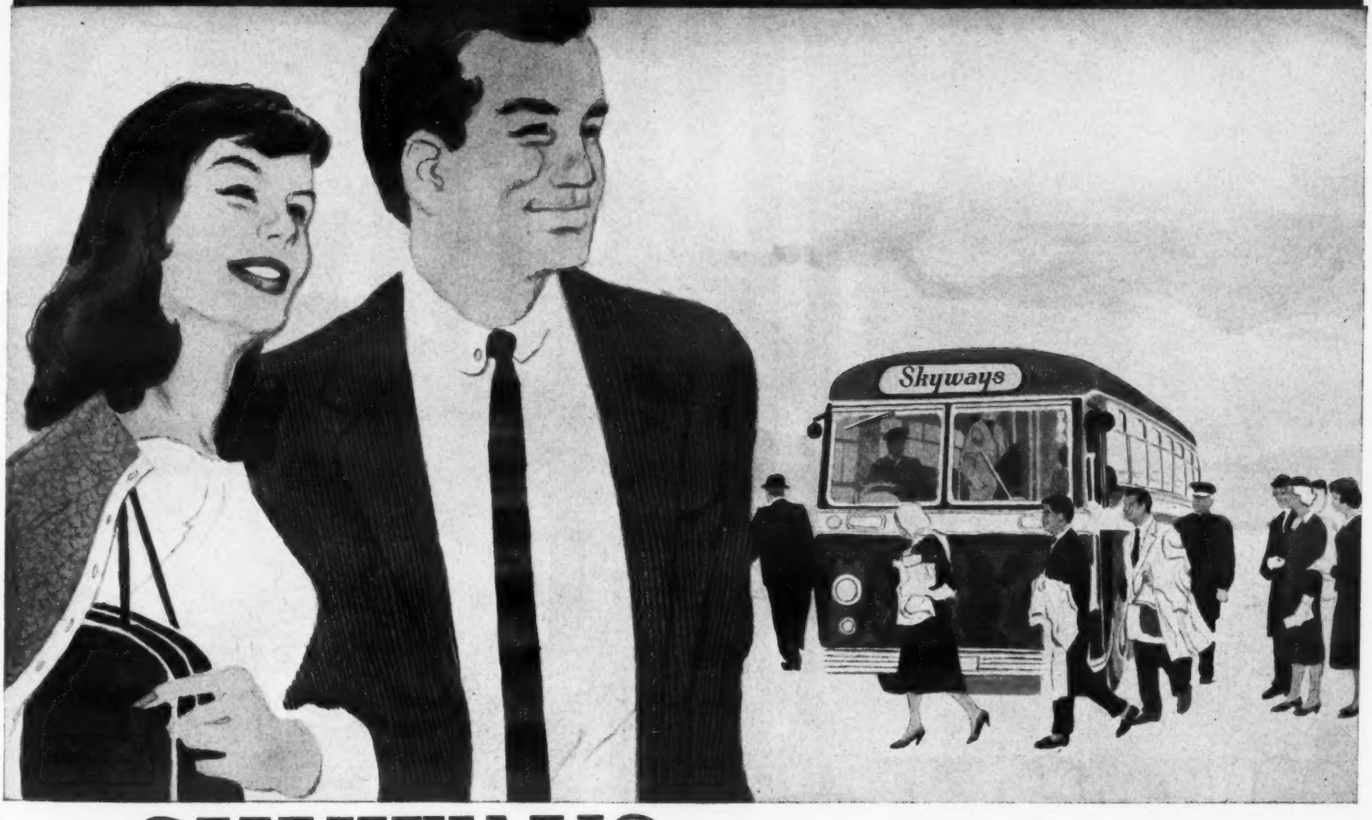

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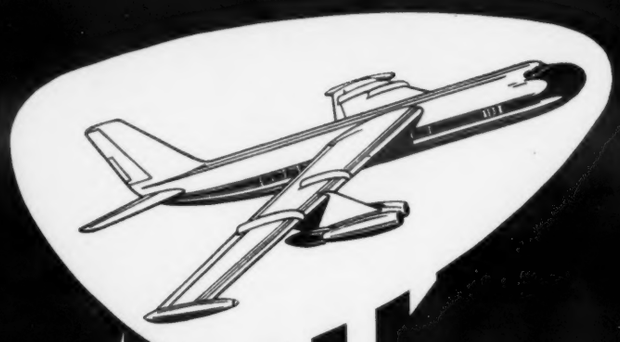

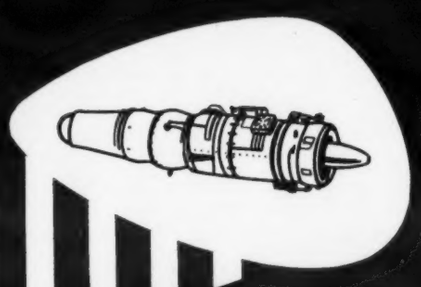

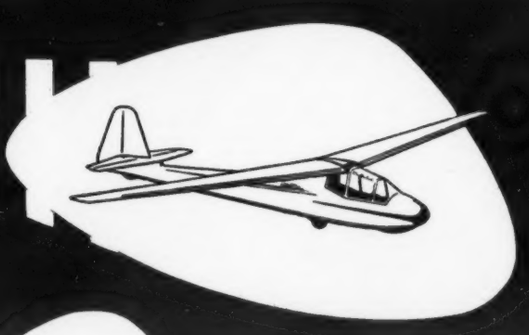

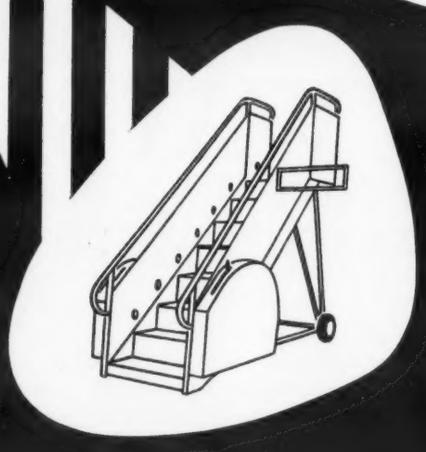

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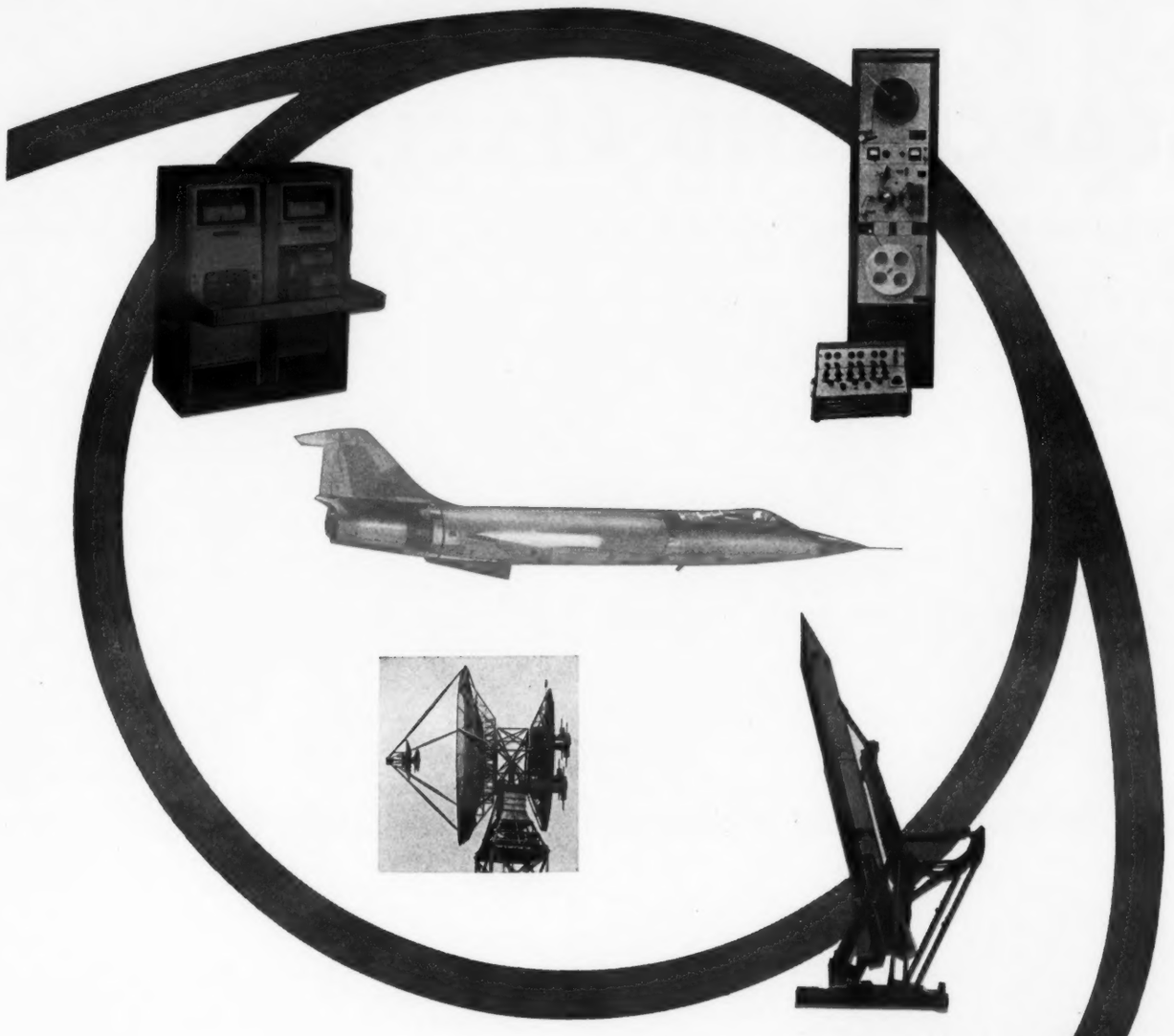

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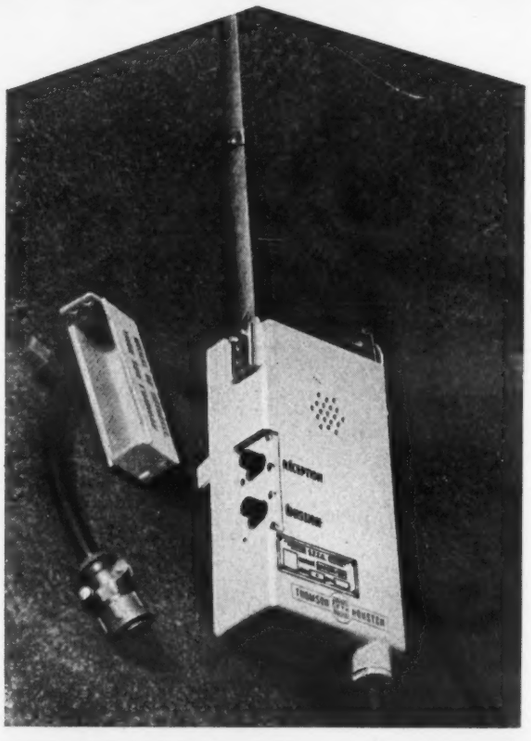

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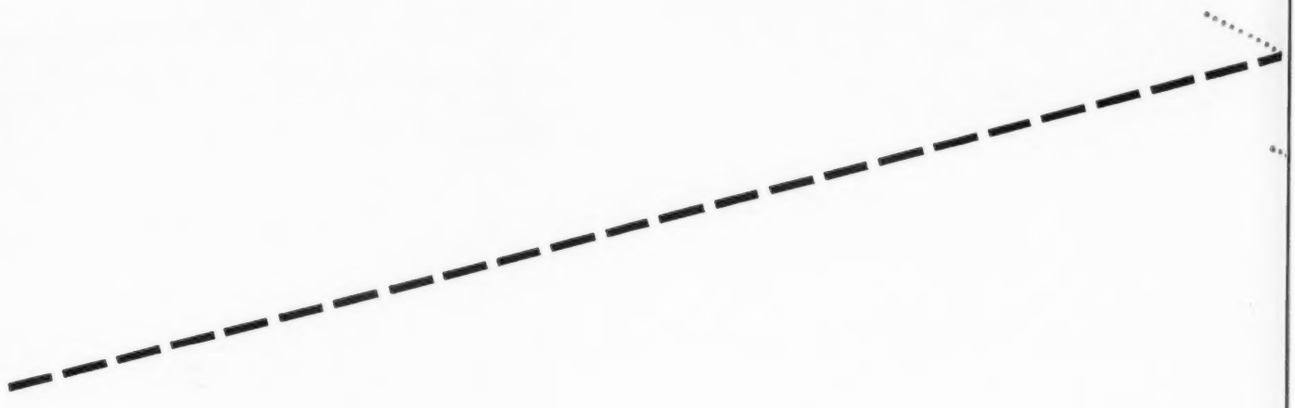

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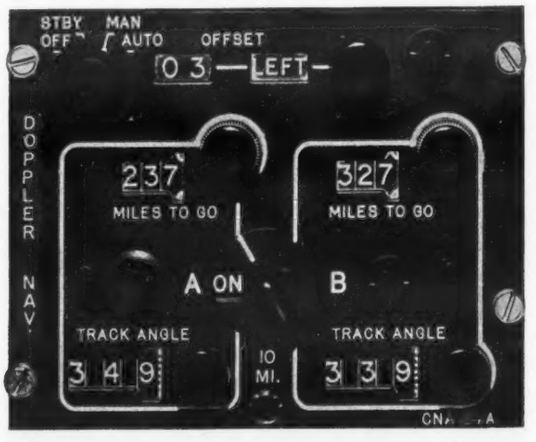

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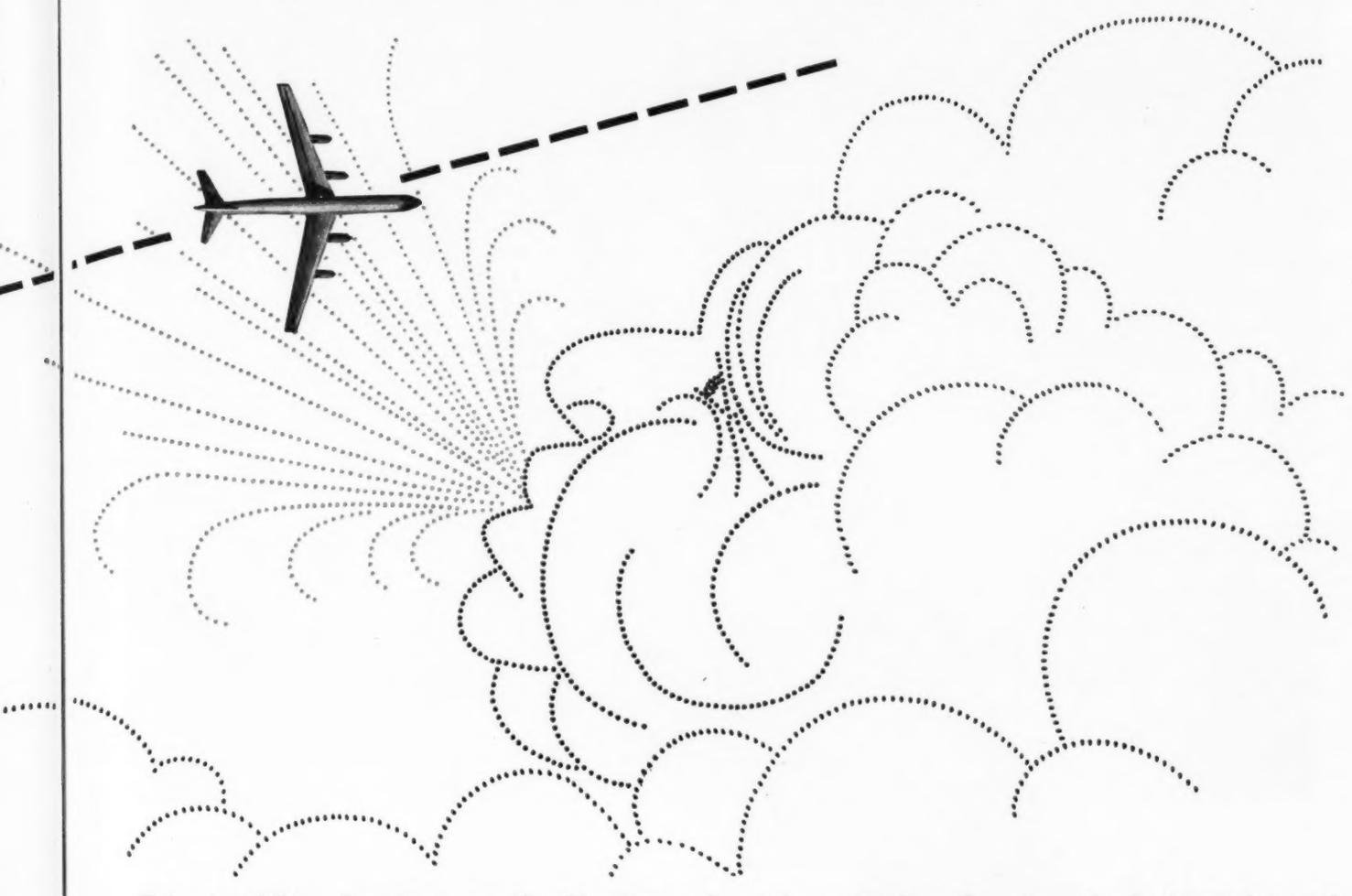

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Did the "Josephine Ford" Reach the North Pole?

By G. H. Liljequist, Uppsala, Sweden

Gösta H. Liljequist, Professor of Meteorology in the University of Uppsala, Sweden, has been interested all his life in polar expeditions and polar history. Born in 1914, he graduated from Lund University in 1937 and became first a hydrologist and later a meteorologist at Sweden's Meteorological and Hydrographical Office. He joined the 1949–1952 Norwegian-British-Swedish expedition to the Antarctic as meteorologist, spending two years at Maudheim, and was later leader and organizer of the Swedish-Finnish-Swiss expedition to Northeast Land, Spitsbergen during the 1957–58 International Geophysical Year.

In publishing Professor Liljequist's article, Interavia *has no desire to belittle the exploits of Admiral Byrd. The Editors are merely following their normal custom of opening the magazine's pages to the widest possible range of opinions. They will welcome further details or comments on the "Josephine Ford" flight.* *Ed.*

The Fokker F-VII-3m "Josephine Ford" at King's Bay in preparation for the North Polar flight.

At the end of April, 1926, final preparations were being made at King's Bay, Spitsbergen, for the start of the dirigible "Norge" on her flight over the North Pole to Alaska, when a second expedition appeared on the scene. This was the American ship "Chantier" carrying the Fokker aircraft "Josephine Ford." Then on May 7th the Amundsen-Ellsworth-Nobile expedition's "Norge" arrived in Spitsbergen from Rome.

The "Josephine Ford" was the first to leave. With Commander Richard E. Byrd as leader and navigator, and with Floyd Bennett at the controls, she took off at 0037 GMT on May 9th in beautiful weather. She returned to base the same afternoon, having completed her mission: the first flight to the North Pole.

Two days later, on May 11th, the "Norge" started her flight across the Arctic Ocean to Alaska via the North Pole.

The flight of the "Josephine Ford" is of great interest from both a historical and a technical point of view. It still merits a thorough and objective analysis.

The "Josephine Ford" was a trimotor monoplane, built by the Fokker factories in Holland in 1925. The type was designated Fokker F-VII-3m. It is described in "Jane's All the World's Aircraft" for 1927.

The aircraft was equipped with three Wright Whirlwind J-4B engines. They were among the first in the series and had the same maximum output as the J-4A, namely 200 h.p. each at 1,800 r.p.m.

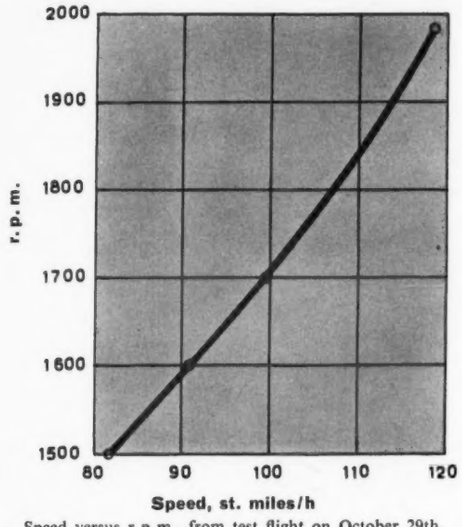
The propellers of the "Josephine Ford" were Reid-Levasseur with twisted steel blades. These fixed-pitch propellers were inferior to the Hamilton Standard Adjustable used with the J-5 engines (240 h.p. each at 1,980 r.p.m.) on the Fokker aircraft which went into production at the company's American factories in 1927. The American Fokkers had a maximum speed of 119 statute miles an hour.

"Jane's" for 1927 gives the "Josephine Ford" a cruising speed of 102.5 m.p.h. or 89 knots (165 km/h). This is, however, a sales value. It is doubtful whether it could have been maintained throughout a long flight.

In studying the flight of the "Josephine Ford," one is immediately struck by the time difference between the outbound and the return flight, 8 hours 26 minutes compared with 6 hours 52 minutes. The difference could be explained by a more or less constant 10.6 knot wind from the north. This would give us the same cruising speed as published in "Jane's," 89 knots. On the other hand, the prevailing weather situation would not lead one to expect a northerly wind as an average

over the whole route, even though Byrd's report contains the information that the wind freshened from the north just after the plane had left the Pole. The reports give the maximum speed of the "Josephine Ford" as 117 m.p.h., but do not mention the cruising speed.

In trying to determine the cruising speed of the plane—especially the speed that would have been used on a very long flight—I have analysed both the cruising speeds of the aircraft on actual flights and the results of a test flight.



Speed versus r.p.m., from test flight on October 29th, 1927 at Anacostia, D. C.; Fokker F-VII-3m, total power 3×240 h. p. (aircraft equipped with wheels).

In the fall of 1927, the "Josephine Ford" was taken on a long tour of the United States, with Floyd Bennett as pilot and Bernt Balchen as copilot. The total distance flown was 7,005 nautical miles, and total time in the air was 100 hours 55 minutes. The tour contained 45 stops. The average length of each flight was 156 nautical miles at 1,000—1,500 feet or lower, and the average time 2 hours 14 minutes.

From the flight log I have computed the ground speed for each of the 45 flights. In 24 cases, the speed was between 66 and 80 knots, i.e. around 72.5 knots. Excluding five flights with very low speed, obviously much wind-influenced, the average speed of the remaining 40 cases is 72 knots. The mean value for all 45 flights is 70 knots.

In other words, the cruising speed of the "Josephine Ford" was around 75 knots or a little lower in the fall of 1927. Just before the tour all three engines had been overhauled at the Wright factories and were in top working condition during the entire flight.

In June 1927, another Fokker F-VII-3m flew from San Francisco to Honolulu, a distance of 2,400 statute miles, in 25 hours 43 minutes, i.e. at an average speed of 81 knots. This aircraft was equipped with more powerful Wright J-5C engines. The plane had a light to moderate tail wind all the way, and consequently its air speed must have been less than 81 knots, say 70 to 75.

During the polar flight, the "Josephine Ford" was equipped with skis instead of wheels, which must have slowed her down by a few knots, particularly as the skis had been damaged in a mishap and provisionally repaired with oars. It seems a logical conclusion that the average cruising speed of the "Josephine Ford" on the North Pole flight was about 70 knots. This is a rather different figure from the 89 knots published in "Jane's."

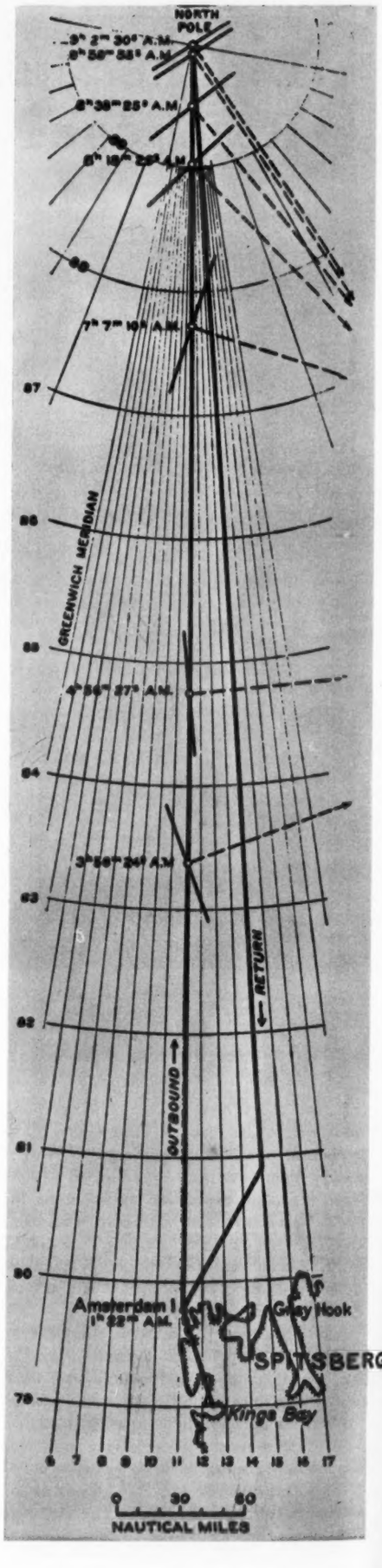
In order to determine whether this low cruising speed may be considered reasonable, I have made a study of the performance qualities of the Fokker F-VII-3m. My data are obtained from a verified test flight made on October 29th, 1927, at the Naval Air Station at Anacostia, D.C., with an American-built Fokker with Wright J-5C engines. The propellers were Standard Steel Adjustable, superior to those of the "Josephine Ford." This aircraft reached a maximum speed of 118 m.p.h. and consequently the maximum speed of the "Josephine Ford" must have been lower than 118 m.p.h.

This test flight was of course performed with a wheel-equipped aircraft. By substituting skis for wheels the parasite drag is increased. A technical expert has assisted me in obtaining a rough value for this increase from photos of the plane in "Jane's" and Byrd's report. The results of the calculations show that in the ski-version the speed is slowed down between three and four knots, depending on the power of the engines.

During a flight, only about 60 percent of maximum available power ought to be taken out for any length of time. For very long flights even this is a somewhat high value. With an output of 60 percent of available power, the speed of the ski-version of the aircraft is found to be 72 knots, as compared with 75 knots for the wheel-version.

The values obtained from the actual flights are thus verified. If we assume the cruising speed of the "Josephine Ford" to have been 75 knots, we have made no underestimate.

Let us now consider the weather conditions during the flight. At the time, meteorological observations were made from Spitsbergen, from northern Russia and from a few places along the Siberian coast and Alaska. They suffice to reconstruct a weather map with a reasonable degree of correctness.



North polar flight of the "Josephine Ford" (extract from National Geographic Magazine, September 1926, p.386).

I have studied the American Historical Weather Maps for the Northern Hemisphere, which give daily synoptic charts for 1300 GMT and also synoptic charts for 0100 GMT analyzed at the Norwegian forecasting centre at Tromsö, where at the time special attention was paid to Arctic weather conditions in view of the "Norge" flight. The two sets of charts differ in details, but are the same in all essentials.

Both show that an anticyclone covered almost all of the Arctic, with a high-pressure ridge extending via the Barents Sea to eastern Russia. This remained stationary from May 8th to May 10th and must have been situated north of Spitsbergen, where easterly to south-easterly winds prevailed.

Estimating wind directions and speeds from the two charts, we find that the Tromsö chart indicates SE-ESE winds of 10 to 20 knots at King's Bay, very light southerly winds between 80 and 88° N and poleward winds from Greenland of about 10 knots in the Pole area. The Historical Weather Maps confirm this picture, though they give the direction of the poleward winds in the Pole area as coming from eastern Alaska or western Canada. These winds refer to 2,000—4,000 feet, where the plane stayed during the flight.

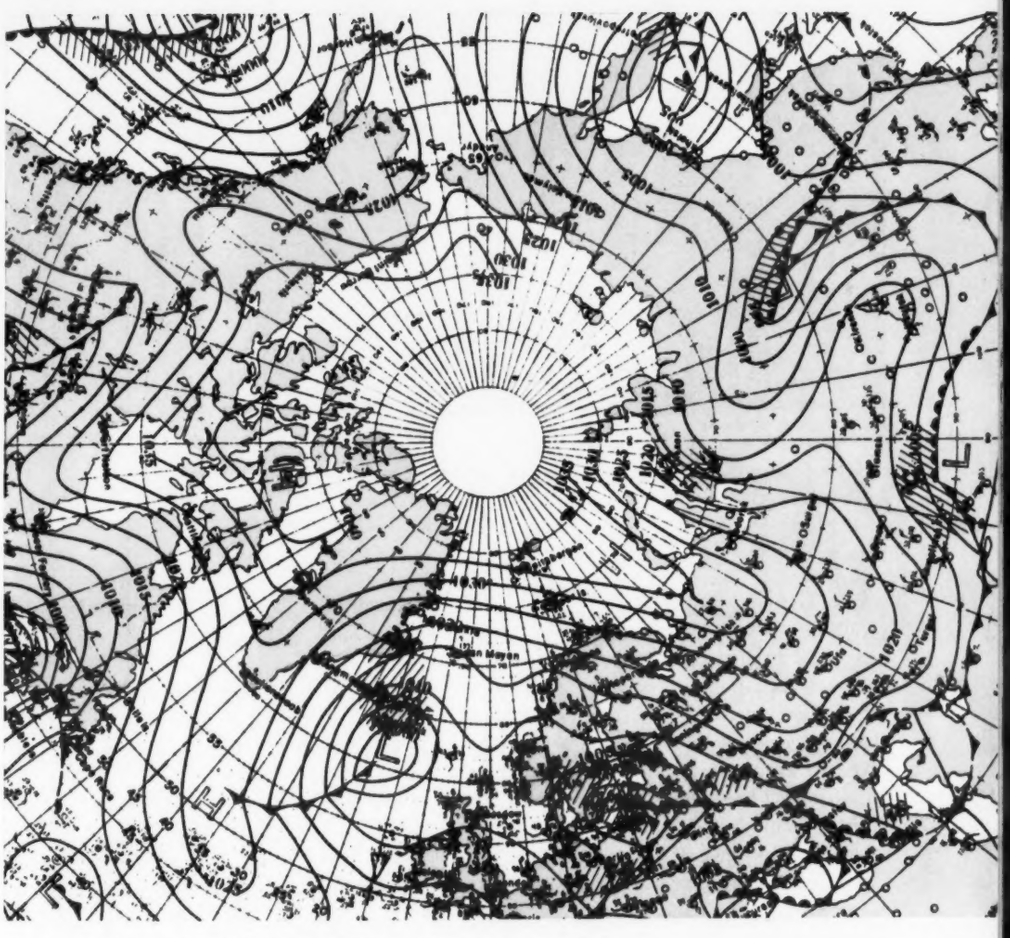
The inference is that the flight may be considered as having taken place in a no-wind atmosphere. At any rate, had a wind worth mentioning arisen between the Pole and Spitsbergen, it should under no circumstances have been found south of about 85° N, since the ridge remained stationary.

On the flight north, Commander Byrd made six astronomical observations with a bubble sextant on the route between Amsterdamöya and the Pole, and four more at or near the Pole. None were made on the homeward flight, the sextant having been damaged.

However, in making an analysis of the flight only the speed of the plane, time and distance plus wind and/or weather conditions are of objective value.

We possess one certain fix on the northbound flight: the northern point of Amsterdamöya at 79° 47′ N. The plane left King's Bay at 78° 55′ at 0037 GMT, passed Amsterdamöya at 0122 GMT, reached the Pole at 0903 and left it again at 0915 GMT. For the homeward flight the only time notation is that Grey Hook (Gråhuken) was sighted straight ahead at 1430 GMT. The time of arrival at King's Bay is not given.

Byrd gives the flight time as "nearly sixteen hours," and Amundsen has written that the returning aircraft was sighted just after 1600 GMT, while Balchen, who was a member of the "Norge" expedition, gives the time of arrival as 1607 GMT. Accepting 15 hours 30 minutes as total flight time and subtracting the 12 minutes spent over the Pole, we arrive at an average ground speed of 87 knots (100 m.p.h.) for the total distance of 1,330 nautical miles.



Weather situation at 13 h GMT, May 9th, 1926 (from Historical Weather Maps).

With our estimated speed of 75 knots, the "Josephine Ford" could in 15½ hours have flown not more than 1,162 nautical miles, bringing it not farther north than 88° 36′ N. Allowing for delays in climbing, the time spent circling over the Pole and the detour around Amsterdamöya on the return flight, a time of 15 hours for the direct flight north and back is more probable. This would have brought the "Josephine Ford" to a point 88° 17.5′ N. To have reached the Pole, the aircraft should have returned to King's Bay between 1830 and 1900 GMT, not a few minutes past 1600 GMT.

The discussion has until now been limited to ground speed in a no-wind atmosphere, conditions which would appear to have prevailed according to the synoptic weather charts.

To have reached the Pole, the plane would have had to have a tail wind of about five knots as an average for the outward flight, and the wind would also have had to change direction and increase to about 22 knots as an average over the entire distance from the Pole to King's Bay on the homeward flight. As already mentioned, the fresh winds can have occurred only during the first half of the homeward flight, in which case they would have had to reach at least 40 to 50 knots from the north.

Such a strong northerly gale should have made itself felt at Spitsbergen soon afterwards, which it did not. The whole of the Arctic was covered by an anticyclone, and a 40—50 knots gale close to this high pressure area is highly improbable.

Commander Byrd's flight in the "Josephine Ford" gave inspiration to a generation of men interested in polar work. However, it would seem appropriate that a committee of aeronautical and meteorological experts be given access to the flight log and all available data to study the question whether in actual fact he did reach the Pole. →→

The Leipzig Fair

Growing Interest in Aircraft Industry Products

The Pirna 017 small gas turbine developed by VEB Entwicklungsbau Pirna was shown at this year's Leipzig Spring Fair for the first time. Picture shows the 017A experimental version with external combustion chamber and spiral manifold. This engine is used to test the main components of the production models.

The German Democratic Republic's aircraft industry has been represented at the Leipzig Fair since the spring of 1957, but it has not been alone in recognizing the growing importance of this meeting point. To an increasing extent the industries of the other Eastern European countries are sending exhibits to the Fair, and of late have even been joined by well-known manufacturers from Britain and France. It is therefore not out of the question that some day these first contacts may develop into regular exchanges between East and West in the aviation sector.

The aircraft industry pavilion

As in earlier years, the leading producers under the "Vereinigung Volkseigener Betriebe Flugzeugbau der DDR"*) united to show their products in a single pavilion. Once again, scale models, mockups and components of the Type 152 four-jet airliner from VEB Flugzeugwerke Dresden formed the centre of attraction. Exhibits included a full-size mockup of the forward fuselage section. A first batch of these aircraft has now gone into production at the Dresden plant, and the first flight of the production model is expected shortly. A systematic export campaign is under way, with particular attention being paid to the Middle East and Arab countries on the one hand, and South America on the other. Representatives of the aircraft industry's foreign trade organization recently spent some considerable time in South America, and it is hoped that foreign deliveries can begin about mid-1961.

The Type 152 has undergone substantial improvement during the past year. The fuselage has been lengthened by some 39 inches to make room for larger quantities of baggage and a larger galley. Thanks to structural improvements, gross weight has been raised to over 112,000 lb, while maximum payload in the version for 58 passengers has risen from 13,840 lb to 19,000 lb, and in the version for 73 passengers from 17,450 lb to 20,000 lb. Production models of the 152 will be equipped for 48, 58 or 73 passengers. Variants for luxury services, pure freight services and mixed passenger/freight operation are also planned.

Whether the Dresden plant can maintain the published delivery schedules remains to be seen. The price of the aircraft is said to be competitive and to bear comparison, for example, with France's *Caravelle*.

Powerplant for the 152 airliner consists of four Pirna 014 jet engines, which have already been bench-tested to ICAO specifications and have successfully met all requirements. Engines of the A-0 series had a thrust of 6,930 lb, but the new A-1 series will deliver a maximum static thrust of 7,270 lb. This increase in power has been achieved mainly by raising engine speed from 8,000 to 8,100 r.p.m. Maximum continuous thrust remains at 6,050 lb, and operating life between overhauls is provisionally given as 1,000 hours, a considerable improvement over last year's figure.

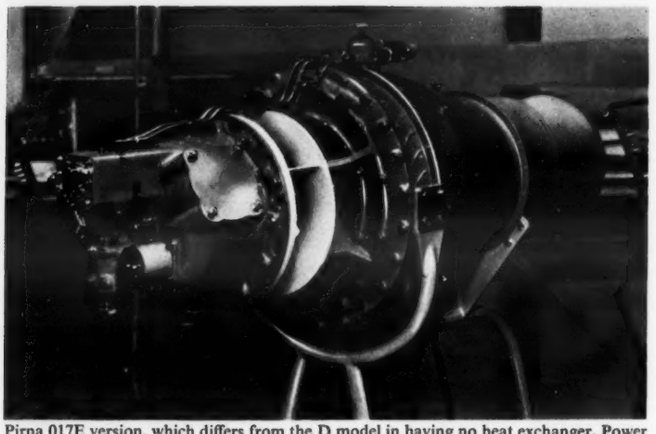
* Association of People's Aircraft Manufacturing Plants of the German Democratic Republic. Chief members are VEB Flugzeugwerke Dresden (development and production of commercial aircraft), VEB Entwicklungsbau Pirna (development of jet engines for air transport and development of small gas turbines), VEB Industriewerk Ludwigsfelde (manufacture of jets), VEB Industriewerk Karl-Marx-Stadt (development and manufacture of aeronautical equipment, and manufacture and repair of piston engines), VEB Maschinen- und Apparatebau Schkeuditz (development and manufacture of ground equipment for air transport; aircraft repair shop; conversion of commercial aircraft), VEB Apparatebau Lommatzsch (development and manufacture of sailplanes). The export of all products of the East German aircraft industry is handled exclusively by Technocommerz GmbH, Berlin.

Inside the assembly hangar at VEB Flugzeugwerke Dresden, where production of the four-jet Type 152 commercial aircraft is under way.

A newcomer to Leipzig: the Pirna 017 small gas turbine

The 017A experimental model of the Pirna small gas turbine has been developed into two operational models, the 017D with heat exchanger and the 017E without heat exchanger. These 130 h.p. gas turbines are designed for helicopters, training, sports and touring aircraft. In addition, they are projected as power units for ground and maintenance equipment, for road vehicles and boats, fire-fighting pumps and—in con-

The Pirna 017D production model has a single-stage radial compressor, annular combustion chamber and two-stage axial turbine. Overall length 43.15 in., weight 440 lb, maximum power 130 h. p.



Pirna 017E version, which differs from the D model in having no heat exchanger. Power is again 130 h. p.; overall length 52.36 in., weight 220 lb. The Pirna 017E is designed primarily for industrial applications.

junction with a generator group—as emergency power supplies.

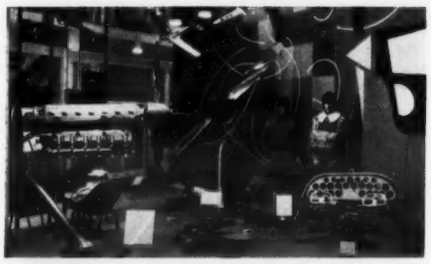
A special structural feature of this turbine is the single-stage radial compressor, through which the air is passed to the annular combustion chamber; a two-stage axial turbine is used, and gas speed in the exhaust diffusor is reduced to roughly 130 f.p.s. It should be noted that the Pirna 017 small gas turbine needs no supervision in operation and that the overhaul life, at 1,000 hours, is relatively long. Installed weight for the 017D version is given as roughly 440 lb and for the 017E as roughly 220 lb.

Aeronautical accessories

The chief accessories developed by the East German aircraft industry include air traffic control equipment on the one hand, and electrical, hydraulic and pneumatic equipment on the other. In addition, VEB Leuchtenbau, of Berlin, showed airport lighting equipment, such as approach lights, runway lights, taxiway lights, etc., all designed to ICAO recommended practices.

The international offering

The Czechoslovak aircraft industry—represented by the Omnipol foreign trade organization, of Prague, showed its well-known lightweight piston engines, v.p. propellers, parachutes, oxygen equipment and instruments, in addition to the L.13 *Blanik* two-seat all-metal sailplane and the cockpit of the L.200A *Morava* twin-engine touring aircraft. Commentaries on the fair suggest that Czechoslovakia has reason to be satisfied with the orders booked at Leipzig: for example, 47 L.60 high-wing aircraft (220 h.p. Praga *Doris*) were sold to the German Democratic Republic, as well as ten Z.226 *Trener* trainers and five Z.326 aerobatic aircraft. A substantial order is said to have been received from the Soviet Union for the L.200A *Morava*, which will be ready for delivery from June 1960 onwards; the production model with complete radio equipment is to be offered on the international market at a price of $44,500.



Participation by foreign aircraft industries was bigger than ever at this year's Leipzig Spring Fair. Above, the stand occupied by Omnipol, of Prague, the Czechoslovak foreign trade organization; below, a section of the Napier stand, with models of the *Eland* propeller turbine and the *Gazelle* gas turbine. The Napier *Spraymat* de-icing system attracted particular attention. English Electric showed an aircraft power supply system designed to meet the latest requirements.

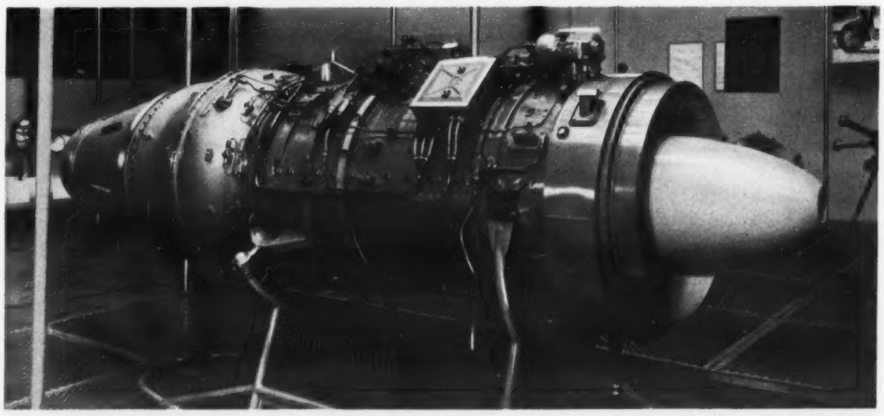
Poland's industry contributed only a few models, including the PZL.102 *Kos* two-seat sports aircraft. And in the Russian exhibition hall the conventional products of the aircraft industry were completely overshadowed by a demonstration of the latest Russian successes in the space travel domain.

Highlights from the other pavilions

Prominent among the British exhibitors were English Electric and Napier, who for the first time had taken an individual stand inside the collective British show. Napier succeeded in obtaining an order for *Spraymat* de-icing equipment for the 152 and 155 commercial jet aircraft. Pye was also represented at Leipzig.

In the "Optical" pavilion, the Munich company Linhof showed the *Aero-Technika* aerial hand camera, well known to *Interavia* readers, and VEB Carl Zeiss Jena presented the newly-developed MRB 21/1818 aerial survey camera with Pinatar 4/210 high-performance lens. ⟷

Pirna 014 jet engine, with a maximum thrust of 6,930 to 7,260 lb. Four of these engines power the Type 152 airliner. The engine has a twelve-stage axial compressor, a combustion chamber with twelve injection nozzles and a two-stage axial turbine with fixed jet pipe. Net installed weight is 2,330 lb; air mass flow is given as 110 lb/sec.



What's in the Air?

AIR TRANSPORTATION

● **The North Atlantic carriers** belonging to the International Air Transport Association operated a total of 6,817 scheduled flights in both directions during the fourth quarter of 1959. Seating capacity offered totalled 444,536, and revenue passengers 275,809, giving an average load factor of 62 percent. Cargo carried totalled 10,217,698 kg, an increase of 45.9 percent over the fourth quarter of 1958, and mail ran to 4,020,396 kg (up 15.3 percent).

● **Trans World Airlines** reports 1959 gross revenues of $348,458,000 and consolidated net profits of $9,402,000, compared with 1958 gross revenues of $284,841,000 and a net loss of $1,764,000. Economies in operation were achieved despite increases in labour rates and higher costs of materials and services which continued to inflate the basic cost of airline operation. TWA's Domestic Division recorded operating revenues of $273,571,000, an increase of 31 percent over 1958, while operating income reached an all-time high of $26,310,000, compared with $4,429,000 in 1958. Passenger load factors averaged 70.5 percent, the highest in the industry. The International Division faced exceptionally stiff competition during a large part of the year from two major airlines offering jet transportation across the North Atlantic before TWA's Boeing *Intercontinentals* came into service. Operating revenues of $65,511,000 were 10 percent below 1958, and the operating loss was $7,107,000. During the current year TWA's fleet of Boeing 707-331s will serve routes as far as Athens, and the company expects a profitable foreign operation in 1960.

● **Capital Airlines,** the U.S.'s fifth largest commercial carrier, has asked the Civil Aeronautics Board for a return to subsidy mail operations, setting its requirements at $12,949,000 over the next 12 months. Net losses over recent years are listed as $1,250,000 in 1956, $2,870,000 in 1957, $437,000 in 1958, $1,750,000 in 1959 and $3,950,000 in the first two months of this year. Total estimated loss over the next 12 months will be $9,731,000, the carrier maintains, blaming its predicament chiefly on the short-haul nature of its route system (with parallel surface transport readily available) and CAB's delay in acting on the airline industry's request for higher fares.

● **Japan Air Lines** has reportedly decided to order three Convair 880-22Ms at a basic price of $3.9 million each, and has asked for Japanese Government approval for the deal. First delivery is expected in May 1961, with the second and third following in June. JAL plans to put the Convairs into service on the southern route to Europe and on routes to Hong Kong, Bangkok and Singapore.

● **Alitalia** has now completed plans for financing its purchase of four Douglas DC-8s and a Link flight simulator. The Export-Import Bank will advance $13.7 million to the Italian credit institute Istituto Mobiliare Italiano, for repayment over a 7-year period commencing in 1961. The balance of the total $24 million required will be provided by Alitalia and by loans from Douglas and Link.

General Paul Stehlin has been appointed successor to General Edmond Jouhaud as French Air Force Chief of Staff.

● **Iberia,** too, has received a loan from the Export-Import Bank, to a total value of $14.1 million, as a contribution towards the financing of three Douglas DC-8s (overall price $20.6 million). Iberia itself is finding 20 percent of the total cost, while Douglas is financing 12 percent.

● **Olympic Airways** is to have a fourth *Comet 4B,* The de Havilland Aircraft Co. announces. This brings the *Comet* order book up to a total of 48 aircraft. The announcement makes no mention of the financial terms of the order, but it seems probable that the order has actually been placed by British European Airways, as was the case with the three earlier *Comets* for Olympic. These aircraft are registered in the United Kingdom as belonging to BEA, and the British carrier has not released any details of the arrangement under which they are being supplied to Olympic. BEA and Olympic are inaugurating a wide range of pooled European and Middle East services this summer.

● **Max Hymans** has been confirmed in office as Chairman of Air France for a further period of six years.

INDUSTRY

● **A major electronics industry** is to be created in Southern Italy under an agreement signed at the end of March between Italy's Istituto per la Ricostruzione Industriale and RCA International Ltd., of Montreal, the subsidiary which handles much of RCA's foreign business activities. Under the agreement, IRI will provide a total of $25 million to build up the industry during the initial phase, while RCA International will contribute technical, commercial and managerial assistance. A special clause in the agreement, which is due to run for five to ten years, provides for the possibility that RCA may at a later date purchase all or part of the facilities set up.

The first step envisaged is to expand the plant and operations of the ATES company (Aquila Tubi Elettronici e Semiconduttori), for which purpose Meade Brunet, an RCA executive, has been appointed Managing Director. Later RCA schools will be established to train Italian personnel, a data processing centre will be set up in Rome, and an electronics research centre created.

The main objects of the programme are to increase Italy's share in electronics production within the Common Market and to contribute towards the economic growth of the under-developed southern regions of the country. At present the Italian electronics industry is concentrated chiefly in the north and meets only some 75 percent of Italian demand for electronics equipment, the remaining 25 percent having to be imported.

● **Avions Max Holste** has received a French Government order to proceed with manufacture of the prototype MH 262 *Super Broussard* with pressure cabin. Transport Ministry funding in 1960 totals 23 million New Francs ($4.6 million). The prototype is expected to make its first flight this year, and the first production model will start flight testing at the beginning of 1961.

Beech Aircraft Corporation is consolidating its position on the world market for business aircraft. A special committee at Wichita, Kansas, is studying the possibility of equipping Beech aircraft with propeller turbines. In France, three Beech 18s powered by Turboméca Bastans *have been successfully tested, and a Turboméca* Astazou-*powered* Travel Air *is at present undergoing flight tests. The* Queen Air *shown in the picture may also be fitted with propeller turbines and a pressure cabin.*

German fighter pilots being trained on two-seat Lockheed F-104F Super Starfighters *over the Mojave Desert, California. On their return from the United States, the six Air Force pilots will train Starfighter pilots in West Germany.*

• **Engineer General Louis Bonte,** long-standing head of the French Air Ministry's Direction Technique et Industrielle, has resigned following "differences in opinion" with Secretary for Air Jean Blancard. He is being succeeded by General Aubinière, who is to be replaced as head of the Salon training school by Colonel Gabriel Gauthier. At the same time, Engineer General Martin, one of Bonte's two assistant directors, has been transferred, at his own request, to the Office Général de l'Air, the agency which handles exports of French aeronautical products.

MILITARY AFFAIRS

• **The British Treasury** has been undertaking one of its periodic reviews of military expenditure, and various items of equipment have been under discussion with the Defence Ministry and the Services.

One item under discussion has been the Vickers/English Electric TSR.2. The Treasury has apparently been trying to cut the bill for this aircraft by whittling down the electronic equipment. The Royal Air Force says that this would restrict the number of roles for the aircraft and is adamant that the full range of equipment will be required for strike, high-altitude interception and reconnaissance; it apparently does not intend to give way on the issue. The RAF envisages the TSR.2's life at about 10 years or even more, with additional roles under consideration for the 1970s.

As the TSR.2 is not scheduled for operational service until about 1963-64, there is obviously a three-four year gap in the RAF strike capacity. At present no aircraft is scheduled to fill this gap, and the only two possibilities are the Blackburn NA.39 and the Lockheed F-104. The NA.39 would fill the bill well, but in the past the RAF has not shown any enthusiasm for adopting naval designs. If the discussions now reportedly going on in the U. K. concerning possible British participation in the NATO F-104G programme come to fruition, then the RAF might perhaps utilize a small batch of this type to fill the gap.

Among new weapons being discussed by the Defence Ministry and the Services are a new type of surface-to-air missile specifically for use against low-flying aircraft, and a standard infantry anti-tank missile for the Army. The Army has had some difficulty making up its mind on warhead size and sophistication for its missile; one school has favoured a large weapon with high accuracy and a heavy warhead, while the other has been pressing for a smaller and simpler unit which could be mass produced. Final decision by the Army and a specification are expected this year.

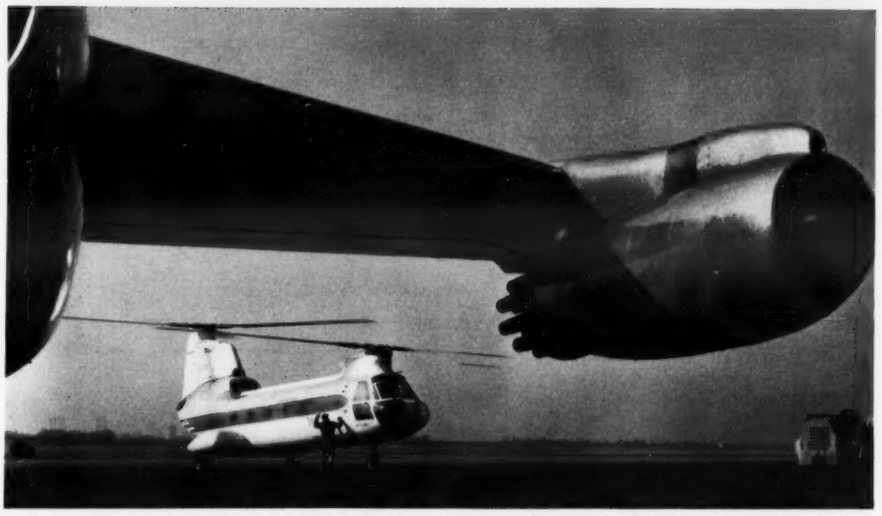
With the formation of British Aircraft Corporation Ltd., some rationalization of surface-to-air weapons is bound to come. Both the English Electric *Thunderbird Mark 1* and Bristol *Bloodhound Mark 1* are in full production, and the *Mark 2* variants (reportedly using continuous wave techniques) are at an advanced stage. The Treasury will probably demand a single weapon for both the Army and the RAF, requiring a choice between the *Mark 2* versions of *Thunderbird* and *Bloodhound*.

The Royal Air Force is shortly expected to order several batches of helicopters from the Westland Group to meet growing Army transport requirements. The types to be ordered are the turbine-powered S.55, the *Wessex* and the Fairey *Rotodyne*.

• **Reports from Ottawa** indicate that the Canadian Government will buy four Lockheed C-130B *Hercules* transports to replace the twin-engine C-119 *Flying Boxcars*, which have been in service with the Royal Canadian Air Force since 1952. Although contract negotiations are not completed, estimated cost of the order is $14 million; it is believed that the Defence Production Department will insert a proviso in the contract for Lockheed Aircraft Corporation to purchase equipment valued at the same amount from Canadian firms.

AIRCRAFT AND POWERPLANT

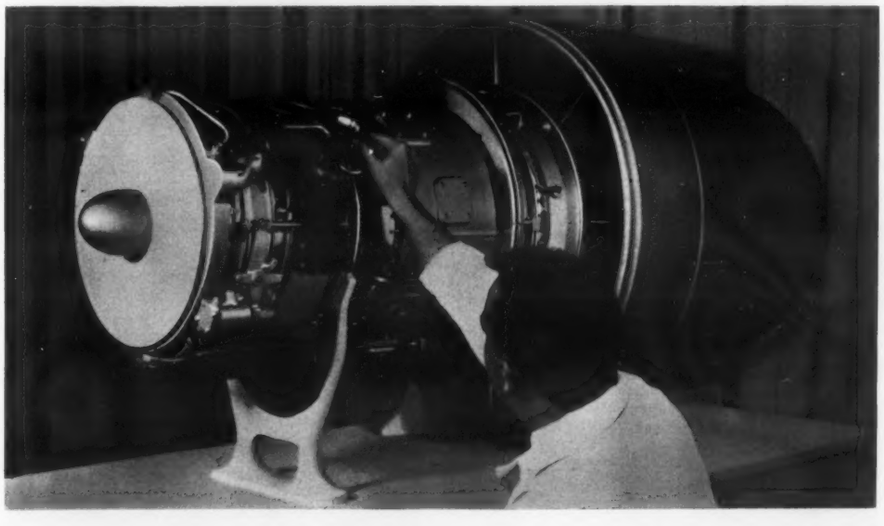
• **The Federal Aviation Agency** has granted type certification to a fourth version of the Douglas DC-8, the Series 40. Equipped with four Rolls-Royce *Conway* engines, each of 17,500 lb static thrust, the Series 40 will have a maximum take-off weight of 310,000 lb and operate from 9,750-ft runways. At maximum cruise thrust the Series 40 DC-8 will have a level flight speed of 515 knots; still air range is more than 4,960 nautical miles. The first *Conway*-powered DC-8 has already been delivered to TCA, and similar models will be operated by Alitalia and Canadian Pacific Airlines.



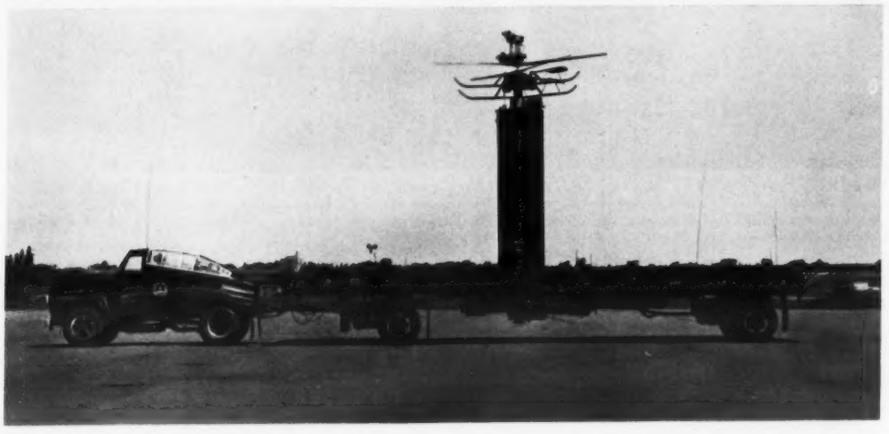
Boeing takes Vertol under its wing: on March 31st, Vertol Aircraft Corporation became a division of Boeing Airplane Company; the company will continue its present activities under the same management. The Vertol subsidiaries Allied Research Associates Inc., of Boston, Mass., and Canadian Vertol Aircraft Limited, of Arnprior, Ontario, are now subsidiaries of Boeing.

Bristol Siddeley Olympus 21, *with a dry thrust of 20,000 lb. The* Olympus 21 *is a derivation of the* Olympus 201, *with 17,000 lb thrust, which powers the Avro* Vulcan 2 *V-bomber.*

Full-size mockup of the General Electric CF700-1 turbofan engine with 4,000 lb thrust. The engine is designed primarily for use on light- to medium-weight airliners and touring aircraft, including the projected McDonnell 220 tourer. The CF700-1 has an eight-stage compressor with an air mass flow of 43 lb/sec, an annular combustion chamber and a two-stage turbine. The current price of the engine is $61,000; an optional thrust reverser is available at an extra cost of $9,000.



The French petroleum company Air Total operates two large refuelling trucks at Jan Smuts Airport, Johannesburg. Each truck has a capacity of 8,000 gallons and the two together can refuel a Boeing 707 in 15 minutes. The towing vehicle is a Daimler-Benz with a 6-cylinder 220 b.h.p. engine. The pump system is supplied by Strüver GmbH, Hamburg.



The Cornell Aeronautical Laboratory's mobile test facility for experimental rotorcraft and ducted fan aircraft; the apparatus consists of a tower mounted on a flat-bed trailer which can be towed at speeds of up to 60 m.p.h. A six-component balance system measures lift, drag and side forces, as well as yawing, rolling and pitching moments of the test vehicle on the tower.

● **Aviation circles in Paris** say that SNECMA is to study the possibilities of modifying the Pratt & Whitney JTF10 turbofan engine for VTOL applications. The studies, which are to begin this year, will reportedly be based on experience gained with the *Atar* engine and the coleopter.

● **The first Spirale,** powered by two Turboméca *Bastans*, has been completed at Dassault's Bordeaux-Mérignac plant and is now being prepared for flight testing. The *Spirale* is a military version of the MD.415 *Communauté* touring aircraft specially designed for overseas operations.

● **The U.S. Federal Aviation Agency** has approved the Rolls-Royce *Tyne* turboprops, Mks.506, 512 and 515, for civil operation. All three engines have previously been approved for civil operation by the Air Registration Board of Great Britain.

● **Boeing Airplane Company** has for some time been considering bringing a medium-sized business aircraft onto the market. One of the projects which has resulted from the company's studies, designated 909, is reportedly designed to operate with four small propeller turbines (Allison or Boeing, each of about 250 h. p.) and carry eight passengers at cruising speeds of about 270 knots.

● **India's RL-3** *Monsoon* low-wing sports two-seater, developed to a design by Renato Levi, is nearing completion. Of wooden construction, the RL-3 is plywood and fabric covered and is powered by an 85 h. p. Continental C-85-8F engine. Wing span is 25 ft; length 19 ft 3 in.; weight equipped 660 lb; all-up weight 1,200 lb; cruising speed approx. 100 knots. AFCO, a ship-building concern, hopes to put the aircraft into production despite expected Government opposition.

● **The Standard Elektrik Lorenz** FAZ 100/0.3 Power Indicator and Reflectometer is used for measuring transmitter power (at any frequency up to a power of 300 watts) and determining the reflection coefficient by comparing the incident and reflected power. Its special application is checking and adjusting transmitters, antennas, load resistors and amplifier stages within the frequency range from 30 to 350 Mc/s. It can be used in fixed and mobile VHF radio and navigation equipment. In combination with the KA 60-1000/0.1 dummy antenna, the Power Indicator and Reflectometer can be used to set up a power test position.

● **The Breguet 941 STOL aircraft** will be fitted with four Turboméca *Turmo III* propeller turbines and Ratier-Figeac propellers. The *Turmo III* has been specially adapted to meet Breguet's STOL specifications and fitted with reduction gears to achieve a propeller speed of 1,200 r. p. m. The installed weight of the engine, which is battery started, is 660 lb; the take-off rating is 1,170 h. p., maximum continuous rating 1,040 h. p.

● **The agreement between Lockheed and Aeronautica Macchi,** under which the Italian company is to produce the CL-402 (LA-60) multi-purpose aircraft developed by Lockheed, was reported in *Interavia*, No. 1, 1960. Macchi's journal "Aermacchi Informazioni" now reports that the CL-402, a single-strutted all-metal high-wing aircraft with a fixed undercarriage, will be offered in a four-seat and a six-seat version. The aircraft can also be rapidly converted for pure freight operations. The powerplant will be a 260 h.p. Continental IO-470-C engine with direct fuel injection and a two-blade constant-speed metal propeller. Performance (four-seater): maximum speed 130 knots; landing speed 42 knots; take-off distance to clear a 50-foot screen 900 ft; landing distance over a 50-foot screen 1,000 ft; service ceiling 18,000 ft; range 520 n. m.

● **The Hélicop-Air Girhel** small experimental compound helicopter has begun tests at Melun-Villaroche. The experience gained from this prototype will be used to establish a design for a 90 h. p. two-seat sports version to meet the specifications for a competition organized by the Service de la Formation Aérienne. A more powerful version of the *Girhel*, which will probably be fitted with a Turboméca *Orédon* turbine, is at the project stage.

● **BMW-Triebwerkbau GmbH** has developed a small jet turbine, the BMW 8025, from the BMW 6002 small gas turbine. The new engine delivers a take-off thrust of 79 lb and has a dry weight of 77 lb. A later development is to deliver 93 lb thrust. The chief application of the BMW 8025 will be as an auxiliary unit for powered sailplanes. It can use any fuel available on the commercial market, although light heating oil or diesel oil is preferable for reasons of safety and economy. The turbine is started electrically.

The rating of the original model, the BMW 6002, has been raised from 50 to 62 h. p. Its speed at full load is 45,000 r. p. m., which can be reduced at the drive end to rates of 3,000 or 11,000 r. p. m. by changing the appropriate sets of wheels in a flange-mounted gear. The turbine is started either electrically or manually. Speeds over 10,000 r. p. m. are regulated by an automatic control. The BMW 6002, which can also run on heating oil, diesel oil, kerosene or petrol, provides power for portable equipment, such as generators, aircraft starters (compressed air and electrical), bilge and deck pumps and aircraft installations. The turbine is produced jointly with the firm Imperia-Aggregatebau, of Düsseldorf, to drive a multi-phase generator.

● **Prototype 04 of the Swiss P-16 combat aircraft** recently made a series of demonstration flights in the presence of foreign aviation experts. These flights were followed by the maiden flight of prototype 05; this lasted 51 minutes, and the aircraft reached speeds of over 540 knots. Unlike its predecessors, P-16-05 has a wing with a spanwise tapered rolled light alloy skin which, despite its lighter weight, is more rigid than the wing used on the earlier prototypes. In addition to two cannon and an automatic rocket launcher in the fuselage, prototype 05 carries four wing pylons for bombs, auxiliary fuel tanks etc. and a number of pylons for air-to-surface rockets.

The Kaman HU2K-1 helicopter, powered by a General Electric T58 turboshaft engine of about 1,100 s.h.p., in production for the U.S. Navy. The helicopter's main undercarriage is fully retractable in two seconds. The electronic equipment is fitted in the nose.

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MEDICAL AIR EVACUATION

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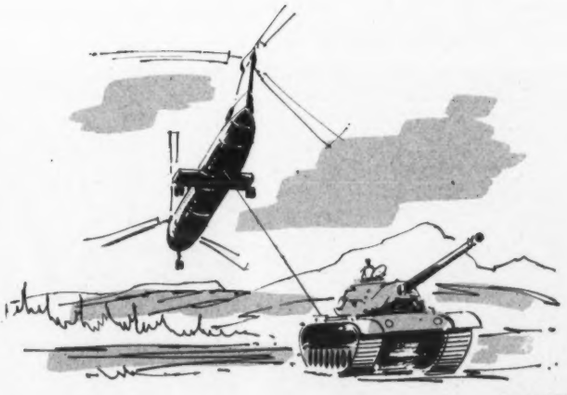


TOWING

THE MULTI-TURBINE POWERED, TANDEM-ROTOR VERTOL 107

was designed around the specific requirements of the Army, Navy and Air Force—the first truly all-mission, all-service helicopter ever built.

The VERTOL 107 prototype recently demonstrated its all-service compatibility to European military leaders during a 16-week tour. The all-weather 107, with its straight-in rear loading ramp, quickly loaded cargo of many different types and sizes—made numerous water landings and take-offs—proved its easy handling, high performance, and stability to pilots of all three services and to commercial operators.

Today's most advanced turbine-powered helicopter —the VERTOL 107 Model II—is ushering in a new era of air mobility for today's military and commercial operations—offers mobility and performance unequalled by any other helicopter.

VERTOL DIVISION
MORTON PENNSYLVANIA
BOEING

New Surveillance Radars for Paris Control Centre and Airports

At the beginning of March this year a new radar installation was placed in service at Paris-Orly regional control centre for the surveillance of air traffic. The equipment incorporates many new features not provided in other existing systems and meets the requirements laid down by ICAO for surveillance radars in 1958. Specification COM 2 stipulates that all jet airports and regional control centres must be provided with long-range radars capable of detecting aircraft at heights up to 45,000 ft and the distances at which jet aircraft normally begin descent.

*

The radar equipments in current use throughout the world, in particular the many installations in the USA and Western Europe, are still far from complying with these relatively modest requirements. As the need for higher-performance radars has become increasingly urgent, the U.S. Federal Aviation Agency has recommended that the peak power output of radars in the USA be raised from 500 kW to 4,000 kW as soon as possible. This is, however, purely an emergency measure, as the useful range of a radar station increases only in proportion to the fourth root of its mean power output.

In France, where the number of radar installations is relatively small, it was decided to proceed along different lines and develop an entirely new system which would have not only increased range, but a number of other refinements. This system is designed for the four French regional control centres of Paris, Bordeaux, Marseilles and Lyons, and for the local control centres at Orly and Le Bourget Airports.

The ICAO requirement specifies a range of the order of 125 miles. In addition, the quality of the radar image must not be affected by rain, snow or hail returns, in other words it must be possible to switch to circular polarization. As circular polarization diminishes the range by 15 to 20 percent, the radar had to be designed for a range of about 160 miles with linear polarization.

Furthermore, the specifications stipulated a blip/scan ratio of 90 percent; in other words, out of every 100 revolutions of the antenna, at least 90 must produce useful echoes. This is essential for the evaluation of radar data by electronic computers.

In order to keep the radar picture as simple and easy to interpret as possible, it was necessary to suppress unwanted echoes and all other interference which might obliterate the screen. The echoes of stationary reflecting surfaces, such as buildings etc., also had to be blanked.

*

The *CR 3 long-range surveillance radar* installed at Orly meets these requirements and is considered to be the most modern of all systems at present in operation. It was built by CSF (Compagnie Générale de Télégraphie Sans Fil) in collaboration with the aviation authorities.

The local control centres at Orly and Le Bourget will be provided with *Type SRE surveillance systems* which, apart from the considerably smaller antennas, have the same design as the CR 3. Both SRE systems will be installed this summer.

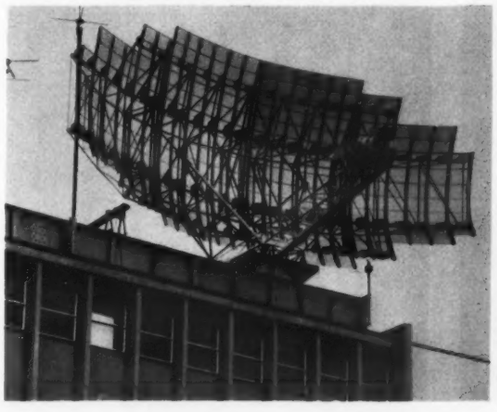
The accompanying range diagrams for small and large jet airliners show that the ICAO minimum performance requirements have been exceeded. The figures relating to very high altitudes have, of course, been extrapolated, but all the other data are based on the results of actual flight measurements.

A comparison of the radar images with and without clutter elimination shows the extreme efficiency of the device. A television link, also developed by CSF, transmits the radar image from the Orly regional control centre to the control towers at Orly and Le Bourget Airports. This system has already proved its worth in the USA.

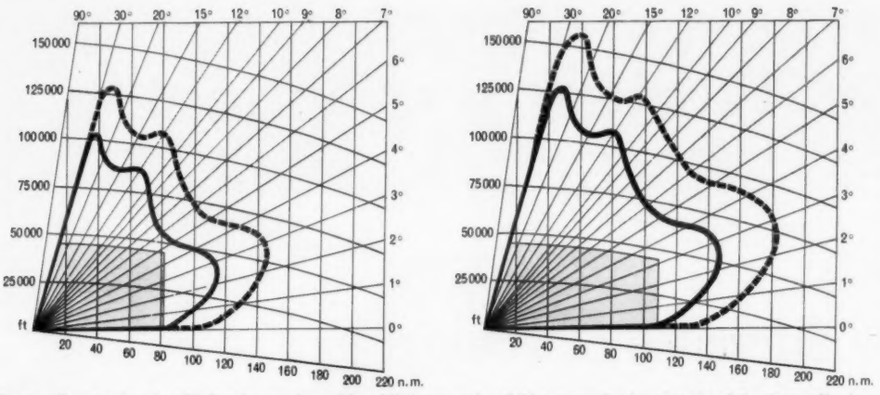
Technical details

As the conditions for propagation, reflection and reception vary with the weather, type

Antenna of the CR 3 long-range surveillance radar for Paris-Orly regional control centre.



Antenna of a local control radar (SRE) as planned for the control centres of Orly and Le Bourget jet airports.



Range diagram for the CR 3 radar station with a blip/scan ratio of 90 percent for jet aircraft of the *Caravelle* class (left) and Boeing 707 class (right). The unbroken lines show the range with circular polarization, the broken lines the range with linear polarization. The altitude and range coverage required by ICAO is hatched.

of aircraft and other circumstances, CSF adopted a frequency diversity system, in which two pulses are transmitted one after the other with a frequency spacing of 30 to 45 Mc/s in the 1,300 Mc/s (23 cm) band. This means that two echoes will also be received. As propagation and reception conditions are different for each set of waves, the probability of receiving usable echoes is greatly increased, particularly as the signal strengths of both echoes can be so combined by addition or multiplication processes as to ensure optimum presentation.*

In order to ensure that both sets of waves can be used together without interference, two separate transmitter/receiver units are provided, both working from the same antenna. If one unit breaks down, the other can continue operating on one frequency, though in this case the range is reduced by about 20 percent; this is an advantage which should not be underestimated.

Storage tubes are used to eliminate unwanted echoes, thus avoiding the necessity for reducing receiver sensitivity. The latter process would weaken the pulses and thus cause a reduction in range. Storage tubes can also be used to suppress fixed echoes; here the pulse recurrence frequency can be wobbulated so that no useful echoes are lost through range ambiguity.

The peak power output per transmitter/receiver unit is 2,000 kW. In the long-range CR 3 system there is a choice of three pulse lengths: 4, 2.5 or 1.5 microseconds. The corresponding pulse recurrence frequencies are 250, 400 and 700 p.p.s. The pulse lengths for the approach control stations are 2.5, 1.5 or 1.25 microseconds at PRFs of 400, 700 or 800 p.p.s.

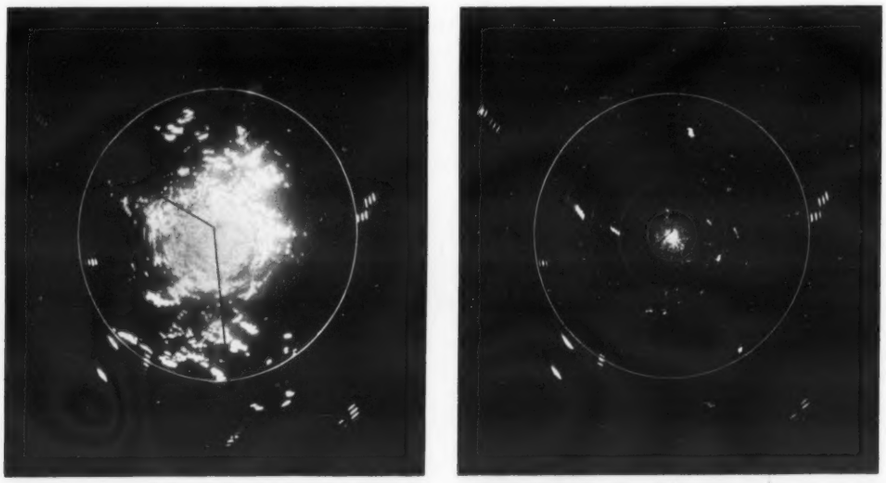
Antenna data

	CR 3	SRE
Length	39.4 ft	18 ft
Surface area	560 sq. ft	118 sq. ft
Speed	6 r.p.m.	12 to 15 r.p.m.
Horizontal beamwidth	1.3°	3.2°
Vertical beamwidth	30°	50°

There is no doubt that these new developments, the CR 3 long-range surveillance radar and the SRE local surveillance radar, have greatly increased the safety of jet traffic and the speed with which it can be handled. ←→

* cf. "Progress in Radar Engineering," *Interavia* No. 7, 1958, pp. 742 et seq.

Radar picture without moving target indication (left) and with moving target indication (right).



The Remarkable Morons:

Probably one of the most overworked—or should it be mis-used—words in the English language at the present time is the term "computer." The impact of the high speed electronic digital computer with its undoubtedly remarkable potential powers, has led to the use of the name computer for devices from 10-shilling slide rules to multi-million dollar data processers. There are many different types of device, some of which are "genuine" computers: others had perfectly satisfactory names before the last decade, but are now computers.

*

There are two main streams of these machines, the analogue and the digital. It must be appreciated that an over-simplified picture must be presented here for the sake of clarity, and that there are many variants that fall outside the simple classification adopted in this article.

The analogue computer deals in quantities that may take up any value in the range in use. For example, a car speedometer needle may adopt any position on the scale between, say, 0 and 100 m.p.h. (conditions permitting!). The pointer position is a shaft analogue of the car's velocity which may vary smoothly over the entire range. The 1940 style mechanical fire control predictors were a form of analogue computer, using shaft positions as analogues for calculating purposes. Nowadays, electronic analogue computers frequently use a D.C. voltage as their analogue, and represent by voltages between, say +100 and −100, any quantity that is desired by using appropriate scale factors. One volt equals one mile per hour or 100 miles per hour, as required, to keep the calculations within the full scale capacity of the machine.

The accuracy of controlling or reading a shaft or voltage is finite, and 0.1%, if not the best achievable, is certainly getting near the economic limit. This 0.1% is of the full scale capacity of the instrument and is one of the limitations in using analogue computers. In measuring distance, for example, we expect always to be accurate to a fixed amount. The car mileometer reads discrete units of miles, and whatever the full scale value or register capacity may be, the reading is accurate to the smallest discrete unit—usually one mile.

It is possible to use a similar approach electronically, and use discrete voltages to represent numbers. The simplest and most reliable way of producing a discrete unit is to use the presence or absence only of the commodity, be it a hole in a piece of paper or an electrical impulse on a wire. This leads to the coding of numbers in the scale of two or binary code, where any one column can contain only a 0 or a 1, and not 0 up to 9 as in the more familiar decimal scale. Just as a value of a number can be built up on the decimal scale by having the appropriate number of columns of figures and positioning the decimal point cor-

Capacities and Limitations of Electronic Computers

By A. St. Johnston M.I.E.E., Joint General Manager, Elliott Brothers (London) Ltd.

rectly, so also can any number be coded in binary form by using sufficient columns or quantities of binary digits and placing the binary point. As each column significance can only be 0 or 1 instead of 0—9, so more binary digits are required to represent a number than are decimal digits for the same value. Approximately three times, in fact. The use of the binary scale is, however, entirely restricted to the internal engineering of the computer and thus does not mean that we all have to learn the binary code, except from a sense of curiosity.

*

The method of working of analogue and digital computers is also very different. In an analogue machine a separate piece of equipment is used for each process in a calculation. This is illustrated in *Figure 1*, where it can be seen that to add two quantities A and B together, these are fed into an adding unit, the output of which is A + B continuously, and whatever changes A and B may make, the output gives the sum continuously. Thus can be built up the terms of an equation which might represent the roll of a high speed aircraft in response to cross wind. The effect of a sudden gust of wind on the aircraft is simulated by the analogue electrical circuits of the true life function, but the gust of wind is applied by a switch. The value of any of the terms of the equation after the gust has been applied can be observed on an oscilloscope or pen recorder on the output of the unit concerned. The observer can adjust various parameters such as autopilot response characteristics, and observe whether the roll is suitably damped or dangerously oscillatory.

The use of analogue technique gives the user a feel of the problem without having to carry out real life tests which can be both expensive and dangerous. Thus, the aircraft and missile designers were the first to use the analogue method extensively. Since then the response of atomic piles under various control conditions has been simulated on analogue computers. Car suspension problems under variable load conditions have also been the subject of analogue analysis. The type of problem that is capable of statement in the form of differential equations can often be studied conveniently by using analogue methods.

*

The method of operation of the *digital computer* is very different, and *Figure 2* shows the essential features. Note that there is only one arithmetic organ, the Arithmetic Unit, which is under the guidance of a control unit, with information and instructions coming from the store. The store holds binary coded information which in computer terminology is known as "words" as it represents either numbers or instructions to the machine. The store can be visualised as a series of pigeon holes each of which has its own address.

The basic rhythm of the machine is very simple. The control unit refers to the register, called the sequence register, and draws from the store the word whose address was specified in that register (a register being able to hold one word only). Let us say this word comes from address 22. The word in address 22 is taken from the store and placed in the instruction register. Before acting on this instruction, however, the control unit adds one to the sequence register (turning its content into 23 in this case). The control unit now examines the instruction in the instruction register. Instructions are of the very simplest composition, being essentially of two parts, a function and an address. Let us in this example say it was Add the number held in address 500 to the arithmetic unit. Assuming the arithmetic unit was previously empty, this instruction has the effect of merely placing the contents of location 500 in the arithmetic unit's register. The whole cycle now repeats, but now the next instruction comes from address 23, and this might say Subtract the content of location 73 from the arithmetic unit. The result of this operation will be that the arithmetic unit now holds the result A — B = C, where A was the content of 500 and B that of 73. Other instructions can replace the result in the store—multiply and divide.

So far, the device purely calculates and, although it does this at very great speed, the true power of the digital computer stems from its ability of decision. To continue our example: the next instruction coming from address 24 instead of being an arithmetic type of order might say Test the value now held in the arithmetic unit; if it is a positive number (or zero) do nothing, i.e. neglect the address operation of this instruction, and proceed to the instruction held in 25, etc., but if the present contents of the arithmetic unit register is negative, take the next instruction from the address specified—say, 315—putting this value also into the sequence register so that the next instruction after this comes from 316, and so on.

Thus the machine is given power to take two alternative courses of action depending on a value reached in the calculation. Appreciate, though, that the human programmer who has written down laboriously the programme of instructions must have foreseen every possible alternative that the calculation may take during its course. The machine is in fact operating like a moron—albeit a very fast and accurate one, who carries out scrupulously a previously laid down set of instructions. The exact course that the calculation follows in any particular cycle, however, is determined by the values involved at that time.

Give the machine additional instructions to take in information from the outside world in digital form and means to be able to communicate in return, and the machine can carry out any type of job that it is possible to give to a moron, provided the user is capable of laying down a comprehensive program of instructions for the moron —I mean machine—to operate on. It is for this reason that this type of machine is known as "general purpose," which is a bad term, as the internal speed, storage capacity, instruction code, and particularly input and output capability may make the machine more or less economically suited to any particular job.

However, the principle remains, and the digital computer in many different forms has been applied to laborious mathematical calculations, to commercial accounting operations, to air traffic control, to wind tunnel tests, to process control, to seat reservations, and many more. In fact it may be applied to any job that can be specified completely as a set of instructions, and the form of input and output is suitable. The machine can then carry out its processing fully automatically at the rate of tens of thousands of operations per second.

When one hears the question asked "can a computer do my job?" the answer should be—you tell me. If the potential user can define the job in minute detail and establish the coupling between the machine and the outside world, then he can answer himself whether the computer is capable of carrying out the work automatically. Whether it is economically sound is quite another matter!

*

However, a new era is truly with us, with almost limitless potential. The first industrial revolution occurred when man substituted machines for brawn, now the second is on us, where man has found a substitute for brain—be it only a moron. ⟶

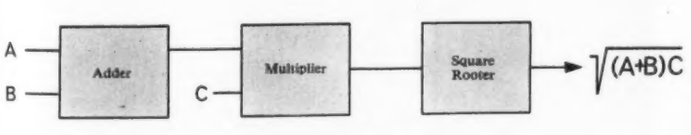


Figure 1: Basic analogue computer block diagram

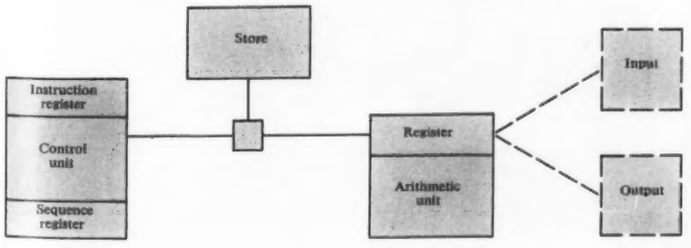
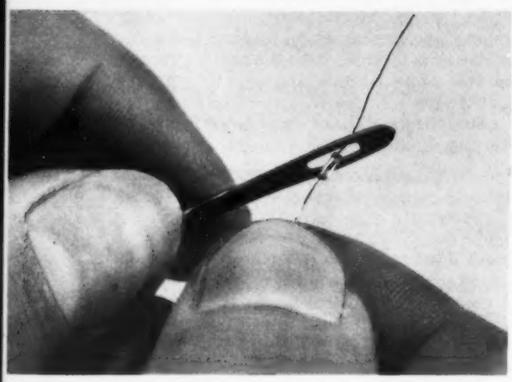


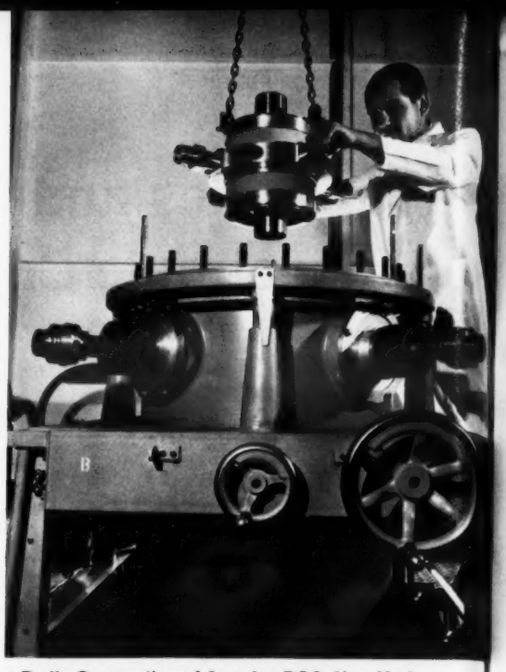
Figure 2: Basic digital computer block diagram

Electronics

Whats New in Electronics?

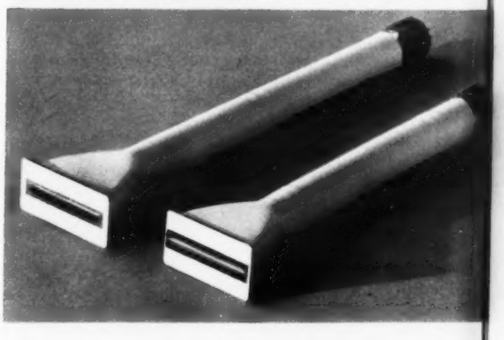


◀ **● Sylvania Electric Products Inc., Salem, Mass.** has commenced mass production of this minute incandescent lamp, the *Mite-T-Lite*, so small that it can be passed through the eye of a needle. The new lamp is expected to have many applications in micro-miniature transistor circuitry and its dimensions are indicative of the advances being made in the miniaturization of components. The very low current and voltage requirements of the lamp make it particularly suitable for use in portable equipment operating from batteries.



● Radio Corporation of America RCA, New York, N. Y. describes this as the world's most powerful electron tube. It is seen being guided into a test chamber to undergo tests which simulate the actual operating conditions of an ultra-powerful transmitter. The tube weighs approximately 150 pounds and can produce 5 million peak watts of long-pulse power at 450 megacycles. It has the potential ability to deliver power enough to explore the possibilities of outer space communications, intercontinental television, missile guidance, super-power radar and scatter transmission on a global scale.

● Litton Industries, Inc., San Carlos, Calif., ▶ exhibited these "*Printapix*" cathode ray tubes at the recent Institute of Radio Engineers exhibition in New York City. The tubes have been developed for direct electronic printing at high speed on non-sensitized dielectric material. A mosaic of writing elements in the printing head of the tube produces a negative charge image on the dielectric material: a developing powder is released as a cloud in close proximity to the charged dielectric and adheres to the charged areas. The resultant image can be subsequently erased for re-use of the base material or fixed by a rapid heat cycle.



◀ **● International General Electric Co., New York, N. Y.** has recently developed a gallium arsenide tunnel diode and expects to make experimental samples available to the electronic industry later this year. The new diode operates at frequencies above 4,000 Mc/s and performs functions similar to those of a transistor. Its operating characteristics enable it to carry four times as much power which greatly extends its capabilities.

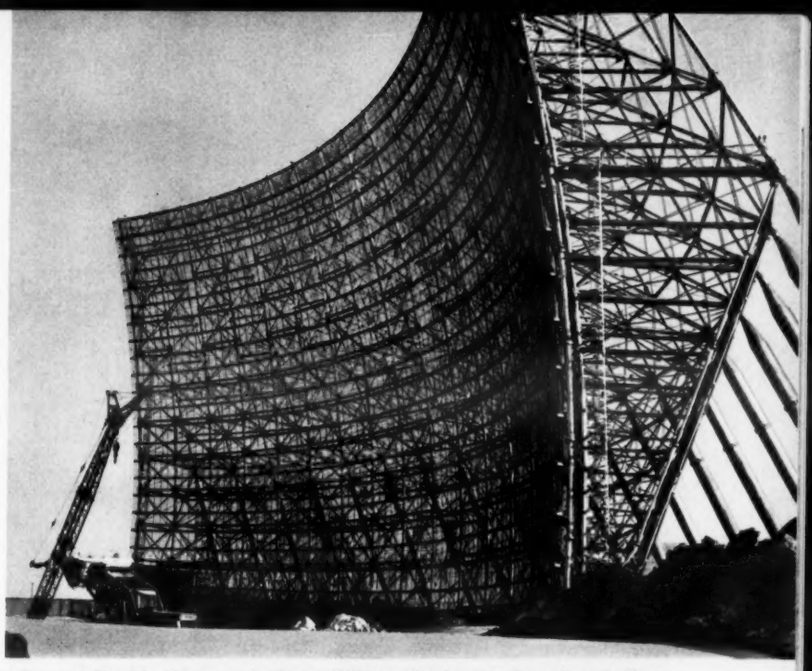
● Boeing Airplane Company, Seattle, Wash., has developed a new type of altimeter for use at high cruise altitudes on jet aircraft or missiles. Called a radioisotope density altimeter, the device measures radioactive back-scatter, proportional to atmospheric density. A radioactive source is mounted in the rectangular frame on the side of the probe, atmospheric back-scatter from the source is detected, amplified and then counted. Laboratory and wind tunnel tests indicate a capability of providing altitude readings accurate to within 500 feet at altitudes above 25,000 feet.

● Stavid Engineering Inc. Plainfield, N. J., has recently been acquired by Lockheed Aircraft Corp. The company is carrying out a wide variety of work in radar and electronic development. In the photo, design engineers are checking the laboratory operation of an airborne fire control system.

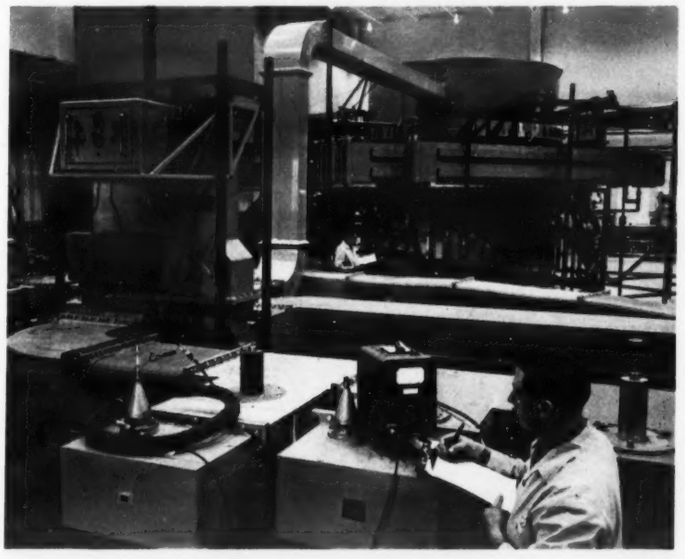
● **Minneapolis-Honeywell Regulator Co. Aeronautical Division, Minneapolis, Minn.,** has developed this *Earth Path Indicator* for use in Project Mercury. The instrument is mechanically powered to operate independently of the capsule's electrical system and will be set by the astronaut after reaching orbit. A complex drive mechanism enables the globe to revolve similarly to the earth around a north-south axis, while at the same time it revolves around a second axis to duplicate the movement of the earth in relation to the capsule's orbit. The markings on the instrument window pinpoint the capsule's position over the earth, and other markings indicate the place the capsule would land when ejected from orbit.

● **Hughes Aircraft Company, Culver City, Calif.** has been responsible for the development of *Frescanar,* a new U.S. Army Signals Corps radar. With this system only one antenna is required to detect the target's range, bearing and altitude. In the illustration the left hand scope displays the range and bearing while the right hand indicates the target altitude.

● **Marconi's Wireless Telegraph Co. Ltd., Chelmsford, Essex,** will supply Type AD 308 transistorized airborne teleprinter receivers to BOAC for its fleet of Boeing 707s. The equipment is used for receiving weather information broadcast on narrow band FSK (frequency shift keyed) telegraphy in the 90—150 kc/s range. The AD 308 is capable of receiving on any one of four spot frequencies in this range and produces a double current output suitable for operating a standard teleprinter. ▶



● **General Electric Company's Heavy Military Electronics Department, Syracuse, N. Y.** under a subcontract with Radio Corporation of America has responsibility for designing, developing, producing, testing and placing in operation the Surveillance Radar Subsystems of the USAF's Ballistic Missile Early Warning System (BMEWS). The torus shaped antenna reflector seen under construction is 165 feet high and 400 feet long. The reflector surface is made up of 2,240 panels bolted to the truss structure and is designed to withstand a six inch coating of ice in winds of 185 mph. (Below) Laboratory tests being conducted on the duplexers and high speed scanning switch used in the BMEW system. This equipment protects the sensitive receiver circuits by blanking off the receiver inputs while the transmitter is radiating.



A Practical Approach to Automatic Instrument Landing

By F. H. Battle, Jr., Airborne Instruments Laboratory, Long Island, N. Y.

Introduction

Prominent among the many problems that have persisted throughout the growth of aviation is that of providing reliable all-weather landing capabilities. The radio and radar guidance facilities (ILS and GCA) that are now available at major civil and military air terminals have proved to be very useful and reliable aids for bad-weather approaches preceding the actual landings. However, their inadequacy for guidance of aircraft during the critical landing maneuver itself is generally admitted; and their demands for rigidly prescribed, uniform approach procedures are coming to be recognized as a serious operational disadvantage.

Interest in modernizing and eventually replacing the current landing aids has recently been renewed, and several new techniques have been actively proposed. But any technique that can provide enough improvements to justify replacement of present-day facilities must stand up under several phases of critical evaluation, including: analysis; hardware development and flight testing; and a trial period of routine operational use.

Operational objectives

The automatic guidance and control of aircraft to actual touchdown on the runway has been accomplished in several recent demonstrations, under controlled conditions. Although such demonstrations are technically impressive, they do not yet represent solutions to the routine operational problems of instrument landing. The future landing system must serve all classes of users, at all airfields; it must be usable under all but the rarest weather conditions, in an efficient, reliable, and fail-safe manner and yet it must be economically feasible—that is, adaptable to existing airfields and aircraft at reasonable cost and with minimum disruptions of service.

In more detail, these objectives include, as one factor, suitability of the guidance facilities to serve aircraft with widely different characteristics: fast and slow approach speeds, high and low preferred holding altitudes and glide angles, rapid and sluggish dynamic responses, etc. If fast and slow aircraft are simultaneously approaching so as to land in rapid sequence (as desired for efficiency), they must fly separate paths during most of the approach in order to avoid overtaking one another. High-density operations by mixed aircraft types will therefore require a wide-sector radio guidance system for coverage of multiple approach courses. Penetrations from high holding altitude (especially by jet planes), and the higher rates of descent that are preferred for stable glides by some recent high-performance aircraft, require that elevation coverage by the guidance system extend to high angles; but the more conventional shallow approach will be in demand as well, so that wide-sector vertical coverage is also required.

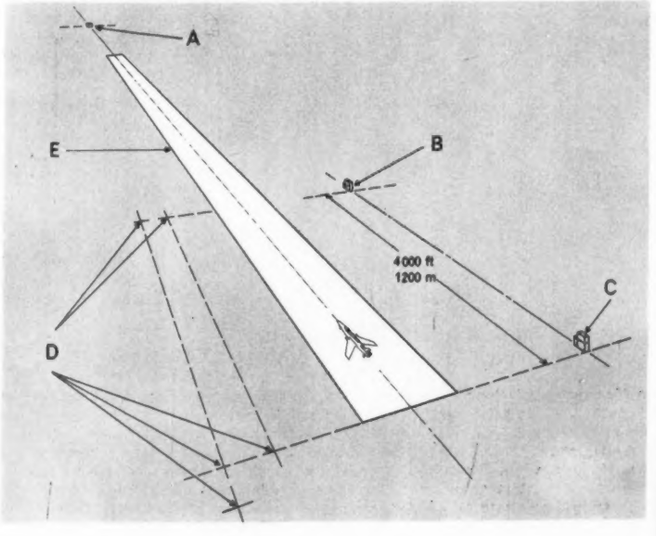
Evidently, reliable system operation under severe weather conditions is required for approach and landing service. The guidance system must also be substantially independent of the terrain and of buildings and other reflecting objects normally disposed about an airport. A narrow scanning beam avoids such reflections at the instant of measurement, so that errors from this source can be virtually eliminated by time-discrimination techniques. The narrow beam also concentrates the transmitted power for reliable penetration of weather. The use of a narrow scanning beam appears to be the only method of avoiding reflection errors that is effective and practicable in this application.

A third objective is that a standard complement of airborne equipment be usable, in a standard manner, for landings at all fields. Since techniques cannot be switched to meet local conditions, the guidance system must serve various runway lengths, with some flexibility of equipment siting relative to the runway. And it must not depend on real estate separated from the airfield (which often is not available). Accordingly, the system should be designed so that satisfactory service is provided when the ground-based equipment is installed entirely within the boundaries of any typical airport.

Another objective for the landing system is traffic-handling efficiency. In addition to the capability for precise maneuvers that adequate coverage would provide, several other aids to efficiency are desirable, and are inherent only in one-way (ground-to-air) guidance-signal transmission. Since all transmitted data apply equally to all users (not having been measured or computed relative to aircraft at specific positions), there is no limit to simultaneous use of the system by numerous aircraft. Airborne derivation of the guidance signals applicable to each aircraft provides the opportunity to suit the use that is made of the system to the aircraft characteristics and current flight condition, and to the pilot's preferences. Airborne sensing also minimizes the routine burden on ground-based traffic-control facilities; the pilot can use the highly accurate guidance data to help control his own position and schedule, with only occasional advice from the ground. Clearly, there are many advantages to an instrument landing system design based on one-way "broadcast" transmissions from the ground, and on independent determinations of aircraft position by individual airborne equipments.

Locations of ground equipment sites

A. Azimuth beam equipment; B. Rear elevation beam equipment; C. Forward elevation beam equipment; D. Alternate elevation sites; E. Runway



The importance of providing common navigational and traffic control service to military and civil users must be recognized. Even in peacetime, there are far too many occasions requiring the joint use of instrument landing facilities for separate, incompatible systems to be considered. The instrument landing requirements of military users are often the most demanding—and they may well be considered the most urgent. Whereas in civil operations the accomplishment of landings under truly blind conditions might be primarily an economic advantage, in a military emergency this capability may become absolutely necessary. Furthermore, many high-performance military aircraft are difficult to land manually, even under good conditions of visibility; automatic control (and better cockpit displays to improve the capability of manual control), when used in conjunction with guidance signals of high quality, would greatly ease the landing job. These considerations and others, such as tactical portability and attempted jamming, have significant influences on the capabilities that should be required of a future landing system.

For economic reasons, the installation and maintenance of ground-based instrument landing equipment should entail a minimum disruption of airport service. Perhaps more important, in the long run, is the burden represented by airborne equipment; not only the size and weight, but also the complexity of airborne components should be considered. These factors vary greatly among the many landing systems that have been proposed.

Finally, but very importantly, the choice of an instrument landing system must be premised on the expectation of reliable service. Failures of the system must be exceedingly rare, and must not have catastrophic consequences. The likelihood of failure is reduced by simplicity both of the system and of its components; the fewer the techniques and equipment elements that are depended on, the more likely that they will all function properly when required. The seriousness of any failure that may occur is reduced by the provision of advance warning; continuous use or monitoring of all system functions should begin early in the approach, before the aircraft is committed to land.

*

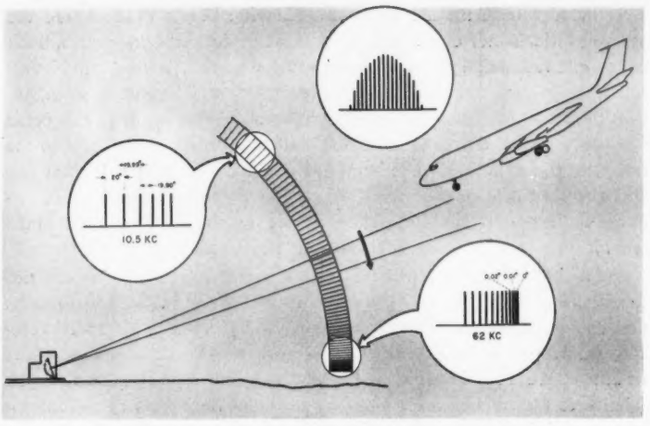
The future operational requirements for a guidance system to provide a universally usable automatic landing capability can now be summarized and interpreted as follows:

1. Wide horizontal and vertical coverage by the guidance system, for efficient service to all types of aircraft.
2. Data transmission by narrow scanning beams, for freedom from reflection errors.
3. Independence of remote real estate, for applicability at all locations.
4. One-way transmission and airborne interpretation, for reliability, traffic capacity and efficiency.
5. Compatibility with automatic flight control, for routine convenience and for advanced military aircraft.
6. Simplicity of implementation, for economical service to all users.
7. Continuous guidance by a single technique, for monitored, fail-safe operation.

Guidance techniques

It is convenient to think of the flight procedures for an approach and landing operation in terms of three consecutive stages. It is also permissible, in connection with guidance system analysis, to consider the horizontal and vertical aspects of the flight path separately during each stage. In terms of both the vertical and horizontal path configurations, then, the consecutive stages of the operation consist of:

1a. Let-down from enroute altitude to approach altitude.
1b. Terminal-area navigation, such as the execution of "downwind" and "base" legs of initial approach.
2a. Establishment of a stable glide toward a point near the runway threshold.
2b. Establishment of a stable alignment of the course with the extended runway centerline.
3a. Flare-out to decrease the approach rate of descent before touchdown.
3b. Maintenance of the centerline course, followed by a yaw maneuver (if required) to remove crab angle before touchdown.



Angle data transmission and reception. The beam angle coding changes during the scan and the aircraft elevation is determined by an average of the intercepted angle values.

Until recently, a fully consecutive procedure was usually followed during an instrument approach; let-down, area navigation, runway alignment, establishment of glide, flare-out, and decrabbing before touchdown. The characteristics of high-altitude jet aircraft, however, make it desirable to execute the horizontal and vertical maneuvers of stage 1 simultaneously. Furthermore, the efficient scheduling that is necessary to achieve high landing rates may require that final course alignment and glide stabilization be accomplished together.

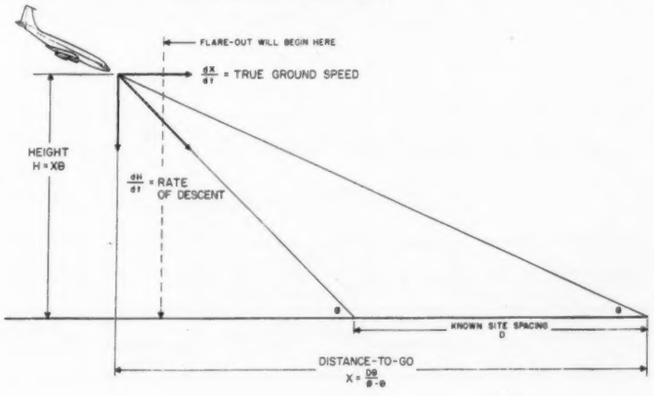
The future need for less leisurely approach procedures must be compensated by the availability of highly accurate guidance signals and improved cockpit displays; automatic path control, by an airborne guidance computer coupled to the autopilot, is a very desirable capability. The computer and autopilot arts are considerably more advanced than the art of providing instrument landing guidance.

Final approach guidance techniques making use of many different combinations of measured quantities are conceivable, and several are under development. However, when all of the routine operational requirements are considered along with the sheer ability to land an airplane, the practicality of most of these techniques appears questionable. For example, magnetic cables provide only a short-range system, without height information; radio altimeters require prepared terrain; tracking radars have traffic-capacity limitations, among others; DME requires complex airborne equipment, etc. This list of disadvantages is far from complete; a check of the characteristics of proposed techniques against the factors that have been discussed reveals serious drawbacks to the general adoption of most of these techniques.

The Airborne Instruments Laboratory system

An example of a system concept that is tailored to operational objectives as well as to technical capabilities is the multiangular technique of radio guidance for approach and landing now being developed by Airborne Instruments Laboratory, a division of Cutler-Hammer, Inc.

Information obtained from two elevation angles. Given the known site spacing D, the height, true ground speed, rate of descent and distance-to-go can be calculated as a function of the two elevation angles at the two sites.



As noted earlier, the use of narrow scanning beams would afford the necessary wide-sector coverage in a way that avoids reflection errors. Such beams can radiate all guidance data that are needed, from ground-based equipment located entirely within the airport. One-way transmissions, rather than the radar principle, will be used; as in radar, however, a narrow beam provides a power advantage and automatically defines a direction to the target. In this application, the interception of a scanning beam by any airborne receiver also allows a transfer of angular reference data into the airborne equipment, so that the angular position of the aircraft relative to the scanning-beam origin can be determined very accurately.

For a complete guidance system, three fan-shaped beams can be scanned from different locations on the ground. One beam is scanned horizontally, and two similar beams—turned flat above the ground—are scanned vertically from separate sites. The origin of the horizontally scanning beam should be at the present ILS localizer site, which is ideal for defining azimuth angles relative to the runway centerline; the height of the necessary structure is only 4 or 5 feet. The two sets of elevation beam-scanning equipment are located alongside the forward part of the runway, and are well separated—by a standard distance such as 4,000 feet. K-band (16,000 Mc/s) antennas suitable for this purpose require vertical apertures of about 8 feet, and the overall height of each elevation-beam structure can be less than 10 feet. It is therefore possible to install the equipment fairly near the edge of the runway, for convenient coverage of the flare-out and touchdown region (required from the rear elevation site only) with a horizontally restricted radiation pattern; however, the site can be 400 or 500 feet to one side before the coverage requirements become awkward.

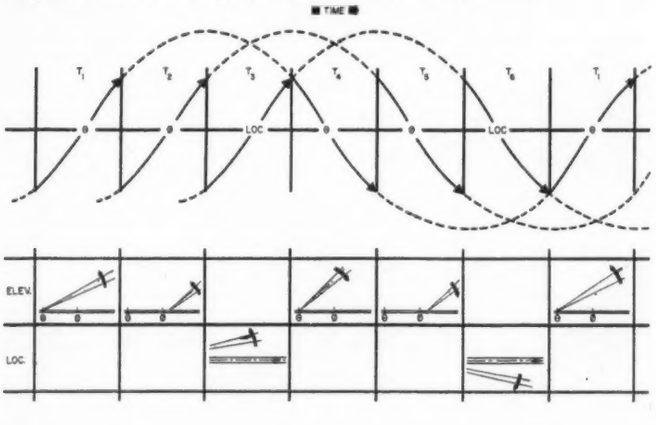
The freedom of choice of lateral offset distances is inherent in the use of flat fan beams, since each elevation angle is measured as though the antenna were on the runway centerline.

The azimuth beam and the two elevation beams will be synchronized in a three-phase scanning sequence. The transmitter for each beam is turned on while the beam scans through its 20-degree sector; and is then turned off while the other two beams successively scan their sectors. The transmissions are thus time-shared so that a single radio channel can be used, and only a single airborne receiver is required. (The transmissions via the three beams are individually coded for identification of the respective angular origins). Synchronization of the three scans is not critical; it can be accomplished over a wired circuit, or by radio reception at each elevation site of the beam signal from the next site to the rear.

The use that is made by each aircraft of the information provided by the three scanning beams can vary, from a simple cockpit display of direct angular measurements, to automatic control of the aircraft through elaborate path computers. In any case, the basic airborne equipment required is a single receiver which incorporates decoding, tracking, and memory circuits.

As each of the three beams scans over the aircraft, the beam identification is decoded and the angular reference data are recovered from the modulation of the beam. The reference data continuously define the instantaneous direction in which the beam is aimed from the ground, and hence define the angular position of an aircraft while it is receiving the beam signals.

Diagram of the time sharing sequence for the three scanning beams.



Since the beam is about 0.5 degree wide, it is desirable to find the average reference angle during its scan over the aircraft; with carefully designed (and relatively expensive) equipment, the angle can thus be found with 0.01-degree precision. For many users, however, a precision and absolute accuracy of 0.1 degree will suffice, and this can be obtained easily.

With the simplest airborne implementation, a glide can be maintained toward the runway threshold merely by holding a constant measured angle from the forward elevation site. Simultaneously, alignment with the runway centerline can be controlled by watching the measured azimuth angle. The cockpit display for these purposes may be a conventional ILS cross-pointer, and the procedure is similar to that used with ILS—except that accurate, proportional guidance signals are available over wide sectors in elevation and azimuth. The pilot can therefore turn onto course with better control, and can choose any glide angle up to 20 degrees.

Distance-to-go is obtainable from the ratio of the forward and rear elevation angles (the standard separation of the two sites being known). Distance and various other quantities can be computed, but this is not necessary in the simplest case: any preselected point at which to start a landing flare-out, or to abort an unfavorable approach, is defined by a preselected ratio, (such as 5 : 1) of the two elevation angles, and this ratio can be detected either automatically or visually. If further guidance is desired during the flare-out itself, the maneuver can be controlled by first attaining and then holding a shallow angle (say, 10.5 degree) measured from the rear site; this finally will result in a suitable rate of descent at touchdown.

The computation of distance from two small angles, though crude during early stages of the approach, becomes increasingly accurate as the flare-out region is approached. It is important to notice that the accuracy of all of the guidance data—distance, height, rate-of-descent, etc.—depends entirely on the accuracy of angular measurements. By modern techniques, the angles can be measured to within 0.05 degree; assuming this accuracy (and taking an unfavorable case of low-angle approach geometry), the distance error may be nearly 800 feet at a mile from the runway, but only about 150 feet with 1,000 feet to go—a typical point for flare-out to begin. At this point, the total error in computed height will be less than 5 feet, which will decrease to about 2 feet at worst before the touchdown point is reached.

Both of the elevation angles will be measured continuously during the approach until flare-out begins, even though the angle from the rear site represents stand-by information until the need for flare-out is imminent. Early in the approach, these two angles can be cross-checked with one another, and with other navigational data. The ability to monitor all elements of the landing system well in advance of full dependence on them is thus inherently provided by this system.

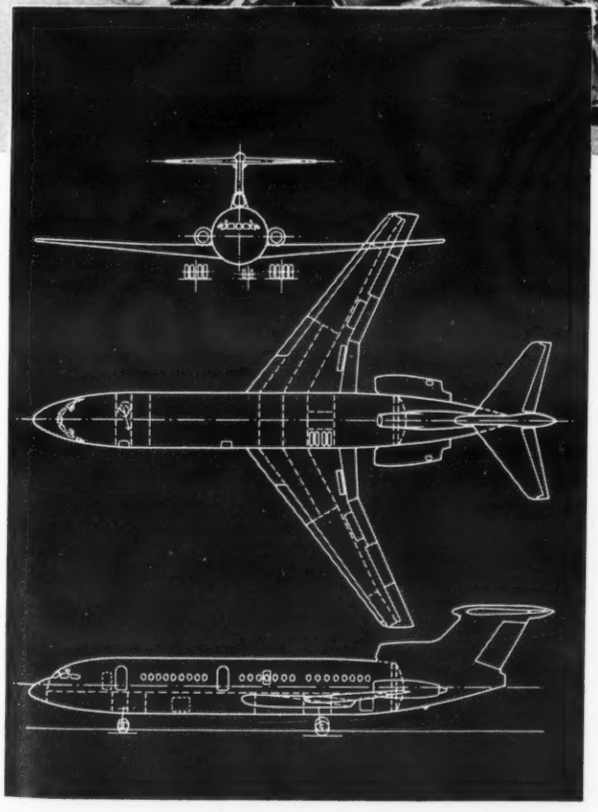
Once the flare-out maneuver is started, there is no further need for data from the forward site; from here on the primary concern is height and its rate of change. Having just measured the true ground speed (before flare-out), the airborne computing equipment can safely assume that the aircraft progresses along the runway as a known function of time, so that the distance from the rear elevation site is known at every instant. The height is thus obtainable as the product of this distance and the measured angle. Finally, the computed values of height and rate of descent just before touchdown allow an accurate prediction of the moment of impact, so that an automatic decrab signal can easily be obtained.

Conclusions

A fully automatic landing capability, which is eventually required for safe and economical operations under all weather conditions, depends on the provision of a final-approach guidance system affording considerably greater precision and airspace coverage than are provided by present techniques.

A suitable future replacement for the current ILS must meet some new operational requirements, as well as many of the old ones that are made more urgent by the commencement of civil jet operations. In addition to better coverage and accuracy, the ultimate system should provide independence of local terrain and siting, a flexible selection of flight paths, and, for fail-safety, continuous guidance from the initial penetration to actual landing by a single combination of equipments.

Full satisfaction of future operational objectives is possible, though difficult. A promising solution is exemplified by a multiangular technique that generally resembles the current ILS, but is considerably expanded in its capabilities. ⟷



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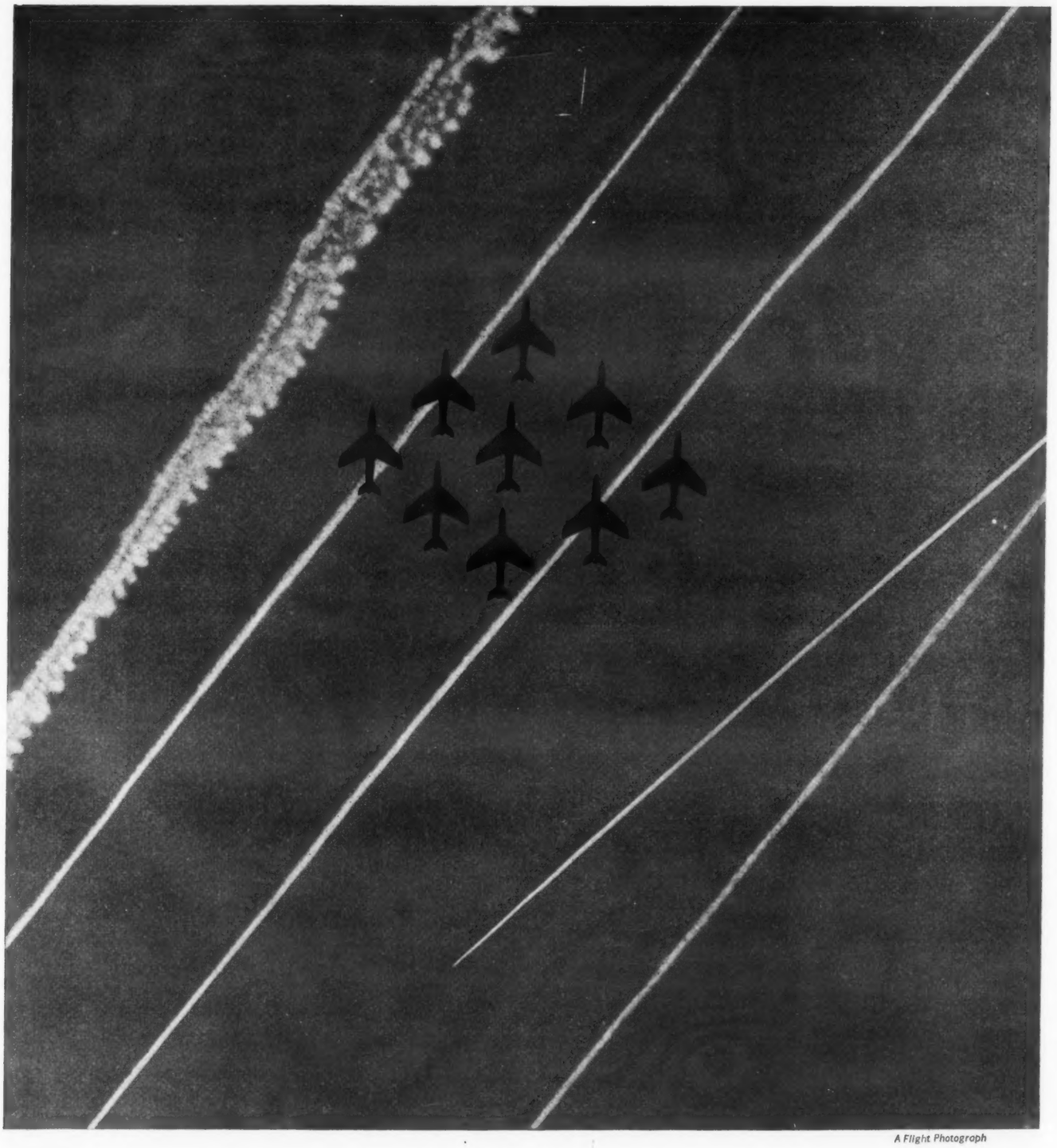


A Flight Photograph

Opening the Polar Jet Service

by Georges Février, Interavia, Paris

On the way to Anchorage. Alaska's snowy mountains include 20,300-ft Mount McKinley, the highest peak in North America.

"We have crossed the 80th parallel. We are now flying abeam of the Pole, which lies 500 miles to starboard."

These words of Captain André Chatel, coming through the loudspeakers to the passengers on board the 707 still all conversation for a moment. For a fleeting instant one imagines oneself an equal of Richard Byrd or Amundsen. On board the Air France Boeing *Intercontinental* F-BHSA making the first Paris-Tokyo trip by the polar route—it is in fact the first commercial jet to fly over the polar icecap—there are a hundred passengers, flying at 40,000 feet and at over 600 miles an hour above the polar icefields.

It has taken only three decades for the heroic efforts, always perilous and sometimes tragic, of the pioneers of the Frozen North [1] to produce this magnificent result. A result which already is taken for granted.

Once again I marvel at the extraordinary sensation of "motionless travel," neither movement nor vibration, and very little noise. What other means of travel can offer such perfection in comfort, to say nothing of speed.

In the polar regions the ordinary navigation instruments are useless, and the navigator of the "Château de Versailles" must fall back on the Sky Compass.

In the bar, with its intimate atmosphere—the soft colours, the flowers, the pictures—it would only be necessary to draw the curtains to imagine oneself at Fouquet's or the Ritz. But through the portside cabin window I can see the sun, large and red, stationary low on the horizon. Is it night? Is it day? One can hardly tell. To starboard by comparison there is the deep indigo of a starry night. Below and far away, the polar mountains, creamy rose and white, rise from the steel-blue icefields.

But to see all this one must make an effort, in fact it requires a constant effort to remind oneself that this is travel. Everything tends to make one forget; the amazing comfort, the superb cuisine, the spacious cabin, and the bar which releases the traveller from the bondage of the airchair, the penalty of air travel until today.

Forward, in the cockpit, the crew work in silence. These huge four-engined jet aircraft, with their size, weight and enormous fuel consumption, demand the continual attention of the pilots and flight engineers. The navigators, deprived for the time being of their usual instruments—useless in the polar regions—work with the Polar Path and Sky Compass.[2]

At Mach 0.82, against a headwind of 85 knots, the "Château de Versailles" continues its route. The lazy sun has risen at last and the snowy mountains of Alaska sparkle, dominated by the 20,000 feet of Mount McKinley, the highest mountain in North America. Seen from above—40,000 feet—it makes little impression.

We have been talking to Anchorage for a long time already, and the descent begins at 2,000 feet per minute. There is hardly time to admire the glaciers when the runway appears. A smooth white ribbon in the wastes of snow. We are well lined up, we touch, we are down. And the thrust reversers stir up an absolute tempest of snowflakes around the fuselage.

The time ? It is 13:10 local time, and we took off from Paris at 12:20. The difference in time zones, together with the crossing of the international date line near the Aleutians and the continual daylight results in some confusion for the traveller. For him there remains only one yardstick—mealtimes. Even so one cannot depend too much on that because shortly before our arrival in Tokyo at 22:00 hours local time on a pitch black night, we will be served our last breakfast of the journey.

Last October, for the Annual General Meeting of IATA, I had already had the occasion to travel by the Air France polar route. On board a Lockheed 1649 we made the journey Paris-Hamburg-Anchorage-Tokyo in a little more than 30 hours. That represents an enormous saving of time in comparison to the Southern route (Paris-Frankfurt-Teheran-Karachi-Bangkok-Saigon-Hong Kong-Tokyo, for example; there are in fact numerous "alternates") for which one should estimate some 50 hours.

But the introduction of the Boeing *Intercontinental* changes the entire picture once again. Twelve hours to fly from Paris to Anchorage, a further nine hours to Tokyo, and the two capitals are now within twenty hours flying time of one another. One lunches after take-off, one dines before arriving at Anchorage, and then one sleeps—8 hours—almost to Tokyo.

The only small inconvenience, once again, is the change in time. The Japanese capital is preparing for bed when the passengers arrive with their wrist watches still indicating nine o'clock in the morning Paris time.

One other annoyance, which will be remedied with time: the various ground services, registration, Customs, police are still not geared to handle 120 passengers at a time. Consequently, while flight times diminish, the delays on the ground increase. Add to this the length of time for transport to the airports, which increases—if one dare say so—with the increase in motor traffic, and the "cement time," as it is termed by the navigators, will soon be equal to the flying time. I exaggerate perhaps, particularly in the case of travelling from the Gare des Invalides, Paris, to the Imperial Hotel, Tokyo. Nevertheless it is already almost true for a journey Paris-Dakar or London-Cairo.

But it would be unjust to blame the jet aircraft for this; it is not because it travels fast that the cars and baggage-handlers are slow.

*

These notes were scribbled at Anchorage while the passengers were stripping the airport shops of all their Eskimo handicrafts "made in USA," and I had intended to finish them after take-off. But our hostesses wanted to deliver their passengers to Japan in the pink of condition. Consequently, in spite of the sun, now high in the sky, in spite of the broad daylight, they insisted that we sleep. The window blinds lowered, the lights dimmed, the aircraft soon became a gigantic dormitory.

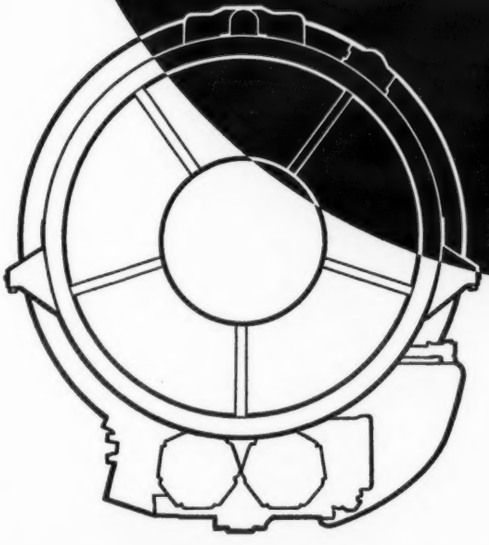
The hours pass even more quickly when one is asleep. Through the clouds, through the darkness, guided by GCA, André Lesieur—who had relieved André Chatel at the controls at Anchorage—approaches the airport.

It is raining. We come down the stairs under oiled paper umbrellas—this is really Japan.

Tokyo greets us with rain. Sheltering under the oiled paper umbrella is Jacqueline Auriol.

[1] In 1897 Andrée, Strindberg and Frankel died in the attempt to fly over the Pole in a balloon. The first successful flight over the North Pole was accomplished by Richard Byrd and Floyd Bennett in 1926 (Fokker F. VII), cf page 589.

[2] Cf. *Interavia* No. 5/1958, p. 404. Polar Navigation, by Paul Comet.



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Rockets, Missiles and Space Vehicles

● **Pioneer V solar satellite**

On March 11th, 1960 a three-stage *Thor-Able* rocket vehicle carrying the *Pioneer V* solar satellite, presented to *Interavia* readers in No. 3, 1960 (p. 287) under the provisional name of *Thor-Able IV*, was launched from the Cape Canaveral test range, Florida. The first stage of the vehicle was composed of a modified Douglas *Thor* with a launching weight of 100,000 lb and a Rocketdyne engine delivering nearly 165,000 lb of thrust on launch. Power for the second stage was provided by an Aerojet-General motor of 7,500 lb thrust; the third stage carrying the spherical 95-lb satellite was propelled by a solid-propellant motor built by the Hercules Powder Company's Allegany Ballistic Laboratory; thrust 3,000 lb.

Unlike earlier Soviet and American solar vehicles (*Mechta* or *Lunik I*, and *Pioneer IV*) the new artificial planetoid circuits the sun inside the earth's orbit, or to be more exact between the earth and Venus. On April 10th *Pioneer V* was more than 4 million miles away from the earth, and its speed was 5,390 m.p.h. By about August 10th it will have reached its nearest point to the sun; the perihelion is reported to be roughly 75 million miles, at which point the satellite will be about 46.5 million miles from the earth. The aphelion, at about 93 million miles from the sun, will be reached early in 1961. According to present reckoning, the *Pioneer V* will take 312 days to orbit the sun.

Another point on which the *Pioneer V* differs from earlier solar satellites is in the exceptionally high power of its transmitter, fed via batteries from solar converters. Whereas the transmitters in Russia's *Mechta* space probe had an output power of around 1 watt and those of the United States' *Pioneer IV* only 0.18 watts, the *Pioneer V* can transmit its signals with a power of up to 150 watts. The transmitters can be switched on and off at will by Britain's Jodrell Bank radio telescope station, thus making better use of the energy stored in the batteries. Signals from the satellite are received four or five times a day, on a frequency of 378 Mc/s, by tracking stations in the United States, Britain and Malaya. If required the 5-watt transmitter can be used to amplify the 150-watt transmitter, so that Jodrell Bank should be able to maintain radio communications up to distances of 50 million miles.

The measuring equipment carried by the *Pioneer V* was described in *Interavia* No. 3, 1960. Main details are repeated below:

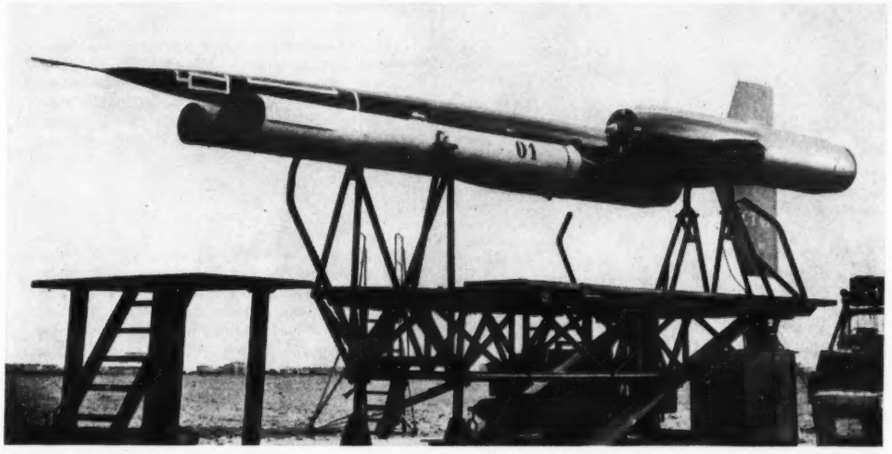
The counter for energetic radiation was developed by the University of Chicago and records above all the sun's so-called hard radiation. It comprises seven cylinders filled with Argon gas in which penetrating particles cause an electric discharge and can therefore be counted.

For recording total radiation a gas-filled ionization chamber developed by the University of Minnesota is used, coupled with a Geiger-Müller counter.

Impacting micrometeorites are recorded by means of a microphone membrane, whose electrical impulses are transmitted back to earth.

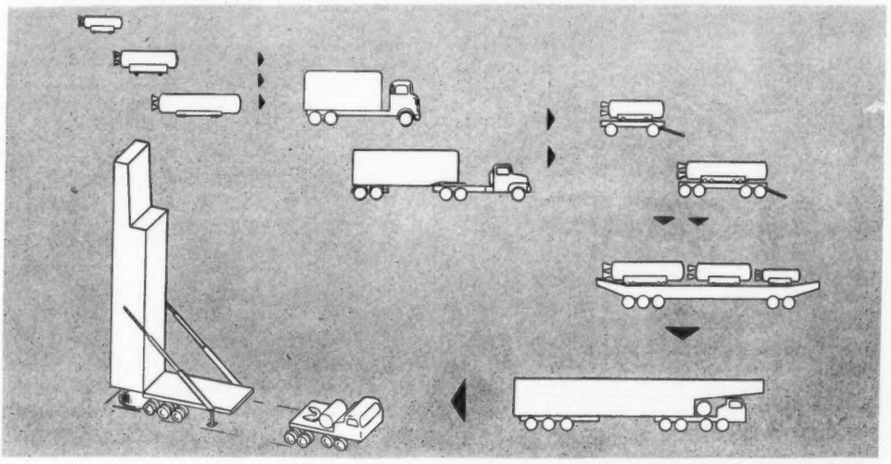
The magnetometer designed by the Space Technology Laboratories to determine the intensity and direction of the magnetic fields in interplanetary space discovered the existence of an "annular flow" in the earth's magnetic field. This ring, which surrounds the earth at a distance of 40,000 to 50,000 miles, coincides with those regions in which—it is at present assumed—solar protons interact with particles in the outermost layers of the earth's atmosphere. Of late the belief has arisen that the magnetic storms caused by this interaction have a certain influence on weather formation on the earth's surface.

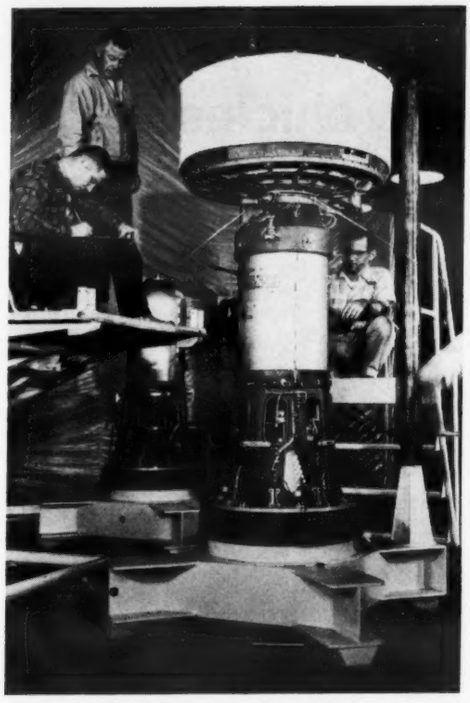
The aspect indicator carried (a photoelectric cell which emits an appropriate signal when exposed to the sun's rays) supplies attitude data to supplement the data measured by the other instruments.



Bell Aircraft Corporation has signed an agreement with France's Nord-Aviation for the licence production in the United States of the Nord CT.41 supersonic target drone. Picture shows the drone in horizontal position on its launching rig. Beneath the fuselage are the two rocket boosters which raise the drone, in 7 seconds, to the speed at which the two ramjets at the wing tips (Nord *Sirius I*) can operate. The CT.41 weighs 5,245 lb on launch and reaches speeds of up to Mach 2.5.

The successful firing of the first stage of the Boeing SM-80 *Minuteman* ICBM on April 5th ushered in a new phase of the testing of this intercontinental weapons system which the USAF plans should become operational by mid-1963. A number of special vehicles, shown in the picture below, have been designed for transporting and handling the solid-propellant missile.
First the rocket motors of the three stages are placed on adjustable trolleys (top left) and then driven to the assembly plant in trucks or trailers (top centre). Here the individual stages are moved onto special trailers (top right) and later onto a common five-axle platform (centre right). Once the casing between the three rocket stages has been added and the individual stages have been assembled to form the complete missile, the finished ICBM is loaded onto a cross-country transport rig (below), which can then be erected vertically above the launching silo. With the aid of this tilting cradle the rocket is lowered into the silo.





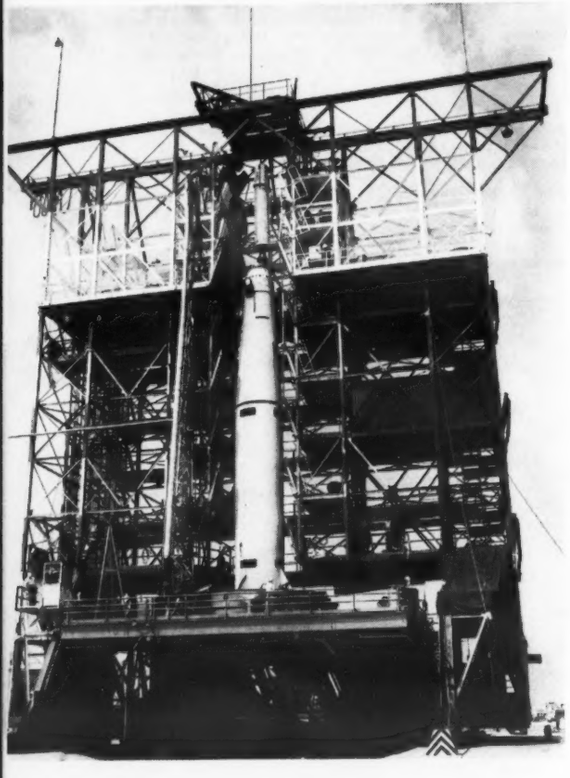
Engineers and technicians from RCA checking NASA's Tiros *weather observation satellite. The satellite is seen here resting on the third stage of the* Thor-Able *vehicle; the solar converters on the drum-shaped body are hidden by the protective cover.*

Tiros I weather observation satellite

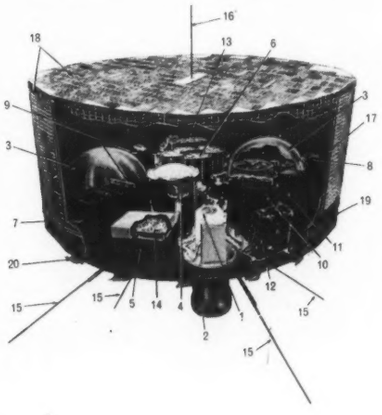
The U.S. National Aeronautics and Space Administration has for some time been planning the launching of a satellite equipped with television cameras to take cloud photographs from great altitude, in the visible and infrared portions of the spectrum, to aid in observation of the overall weather picture. The first of these weather observation satellites, known as *Tiros* (Television Infra-Red Observation Satellite) has now been circling the earth since April 1st, 1960 and transmitting astonishingly clear radio pictures of the earth's surface. As the *Tiros I's* trajectory is inclined at an angle of 48 degrees to the equator, its television cameras cover an area running from Montreal in the north to Santa Cruz in Argentina in the south, including parts of the Soviet Union. *Tiros I* was put into orbit by means of a *Thor-Able* carrier vehicle and circles the earth once every 99 minutes at an average altitude of 440 miles. The drum-shaped satellite body measures 42 inches in diameter and weighs 270 lb. It is spin stabilized (12 r.p.m.), hence moves round the earth on its trajectory like a gyro and turns its two television cameras towards the earth only at regular intervals. The one camera has a wide-angle lens to cover an area of 800 miles square on the earth's surface, while the other has a normal lens covering an area roughly 80 miles square. A magnetic tape recorder stores up to 32 television pictures, which are transmitted back to earth on receipt of an appropriate signal from Fort Monmouth, New Jersey; or Kaena Point, Hawaii. The power required to operate the transmitter is supplied by 9,300 silicon cells on the surface of the satellite casing; these convert the sun's radiation photoelectrically into power. The electrical energy thus obtained is stored in nickel-cadmium batteries.

The Astro-Electronic Products Division of RCA has been responsible for development and construction of the satellite, while technical supervision has been in the hands of the U.S. Army Signal Research and Development Laboratory. Satellites of this kind will probably become of considerable value in overall weather forecasting and in particular in the early detection of hurricanes. In the autumn of this year NASA therefore plans to launch a still heavier *Tiros* satellite (by means of a *Thor-Delta* rocket) for night photographs, and the improved *Nimbus* weather observation satellite is to be tested in 1961.

Assembly of the three-stage Thor-Able *rocket in the large launching rig at Cape Canaveral. The third stage carrying the* Tiros *satellite has not yet been mounted.*



Cutaway drawing of the Tiros satellite: *1. one of the two half-inch Vidicon television cameras; 2. wide-angle camera lens; 3. tape recorders; 4. electronic timer for operational sequencing; 5. television transmitter; 6. chemical batteries; 7. camera electronics; 8. tape recorder electronics; 9. control circuits; 10. auxiliary controls; 11. power converter for tape motor; 12. voltage regulator; 13. battery charging regulator; 14. auxiliary synchronizing generator for television; 15. transmitting antennas; 16. receiving antenna; 17. solar sensor to measure position of satellite with respect to sun; 18. solar cells; 19. de-spin mechanism; 20. spin-up rockets.*



Pioneer V will not return to the earth's vicinity for another five years, but its solar energy converters are expected to be still functioning, so that this satellite experiment promises to furnish valuable new information on space phenomena.

● Transit IB navigation satellite in space

The United States booked a further satellite success at midday on April 13th, 1960. A two-stage *Thor-Able-Star* vehicle carried the 265-lb *Transit IB* navigation satellite into an almost circular orbit which runs round the equator at an average distance of 500 miles and an angle of inclination of 51 degrees. The spherical satellite has a diameter of 36 inches and is equipped with two transmitters, fed by solar batteries and operating on frequencies of 54 Mc/s, 162 Mc/s, 216 Mc/s and 324 Mc/s.

Transit IB can be described roughly as a space radio beacon and can be used as a navigation aid by both aircraft and ships. The ultimate plan is to establish a complete network of *Transit* satellites, to enable ships and aircraft in all regions of the earth to determine their position with an error of less than 200 yards. As the life of the solar batteries is practically unlimited and the satellite itself is expected to orbit the earth for some 50 years, the high costs of such a navigation satellite system would seem to be fully justified. The *Transit* also has considerable military significance, since its radio signals would enable missile submarines and missile-carrying aircraft to determine their position with the greatest accuracy at all times.

Of particular interest is the *Able-Star* second stage of the vehicle, which uses a restartable liquid-propellant rocket engine. In the present state of the art, the only known method of achieving an almost circular orbit is by repeatedly re-igniting the rocket's final stage. Moreover, the satellite attains a higher orbit if the propulsion unit is re-ignited on reaching the apogee of the primary trajectory ellipse. Development of the auxiliary systems and construction of the *Able-Star* second stage were in the hands of Space Technology Laboratories and Aerojet-General Corporation, in collaboration with the USAF's Advanced Research Projects Agency. The basis was Aerojet-General's 10-104 propulsion system. STL then designed new ignition, telemetering, guidance and stabilization systems. Compared with the conventional *Able* rocket, the new second stage carries 2.2 times the amount of propellant (dimethalhydrazine and red fuming nitric acid). Its rated thrust in space is 7,900 lb.

After separation from the *Thor* first stage, the *Able-Star* engine burned for 4 minutes 18 seconds. During the next 19 minutes of coasting the second stage was stabilized and guided into the preselected space attitude. On a signal from the USAF's mobile tracking station at Erding, near Munich, the engine re-ignited and burned for another 13 seconds, whereupon *Transit IB* entered the prescribed circular orbit. After the second burnout the satellite was pneumatically rotated about its longitudinal axis (approximately 130 r.p.m.), and 17 seconds later separated from the *Able-Star* stage.

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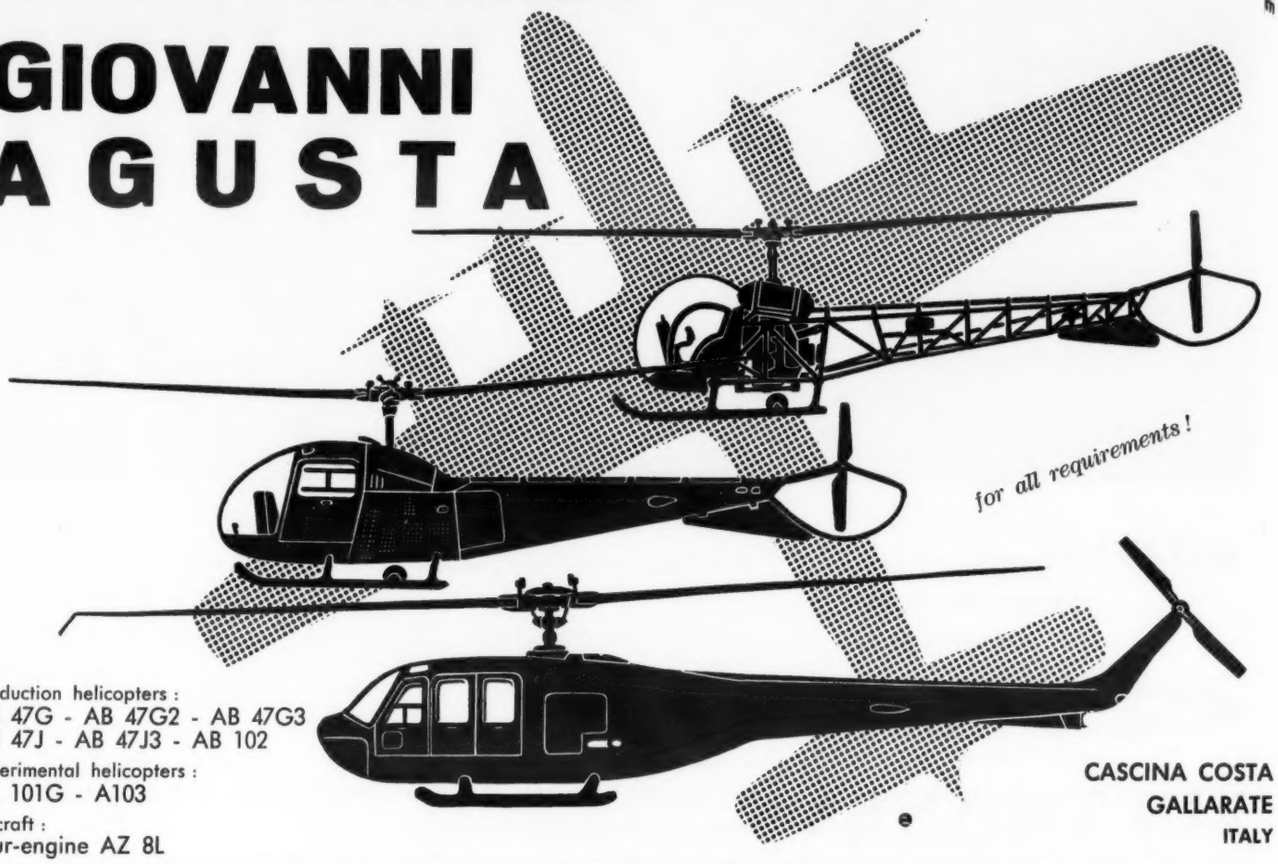

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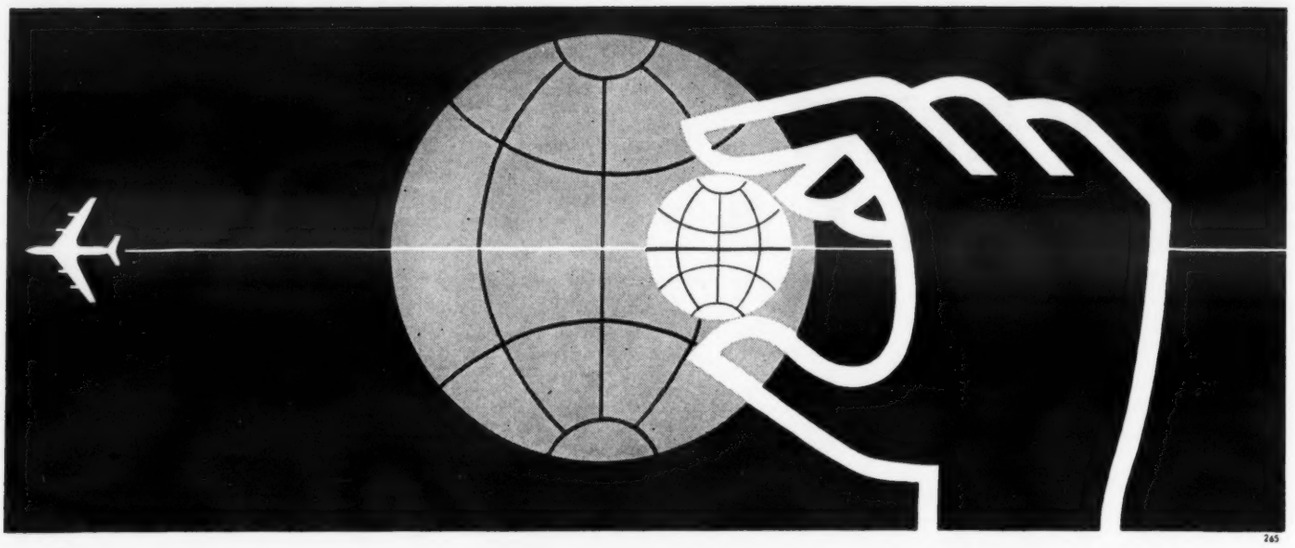

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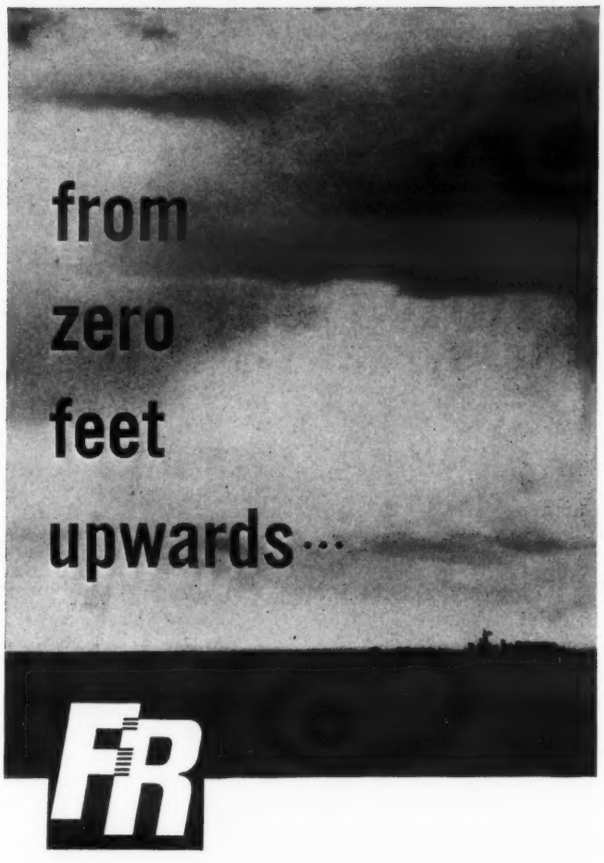

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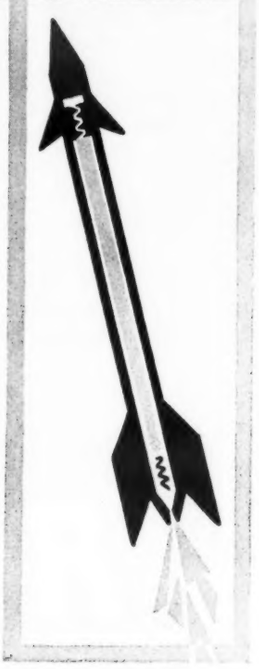

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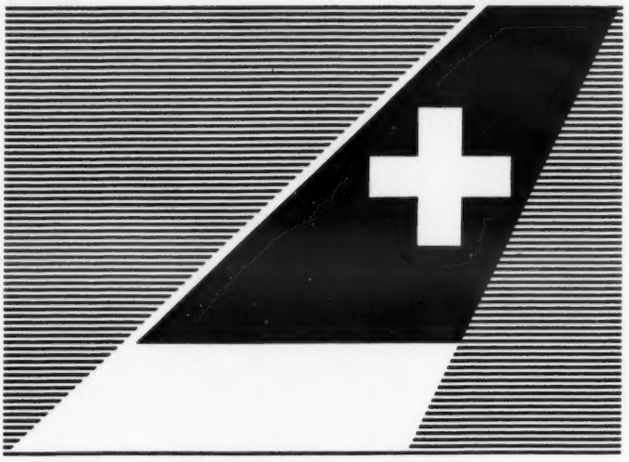

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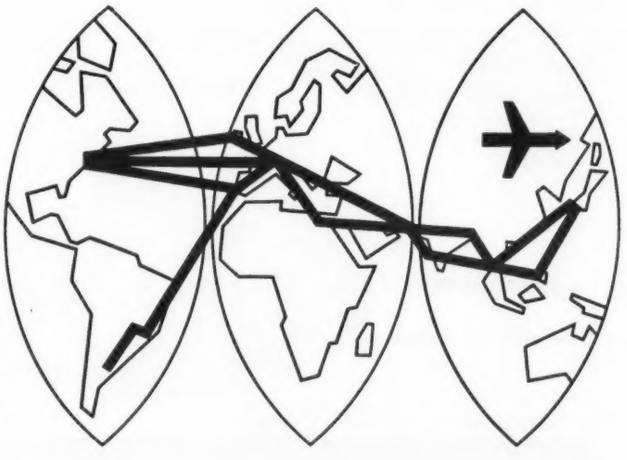

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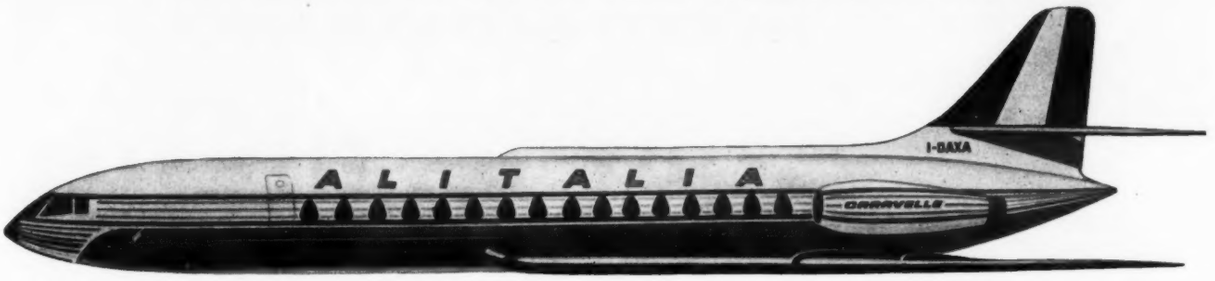

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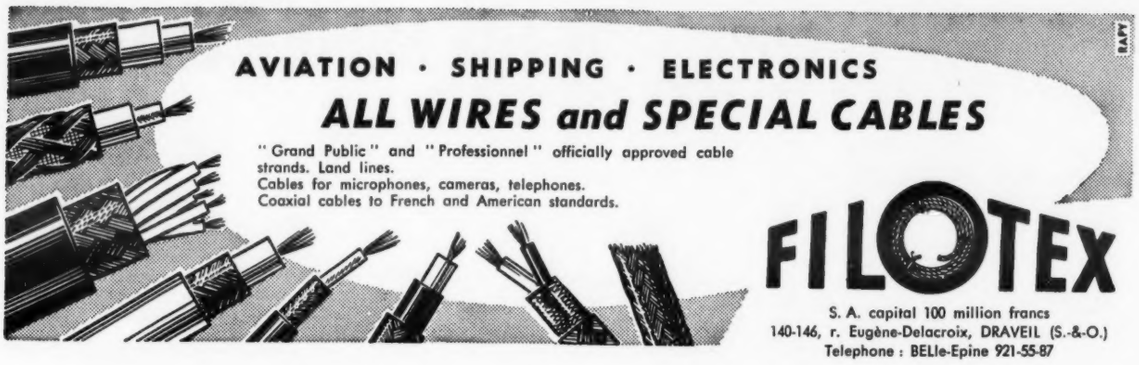
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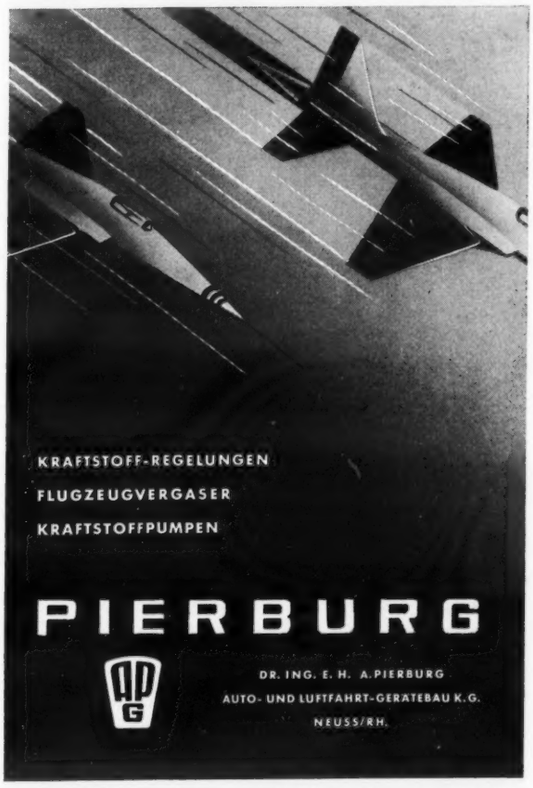

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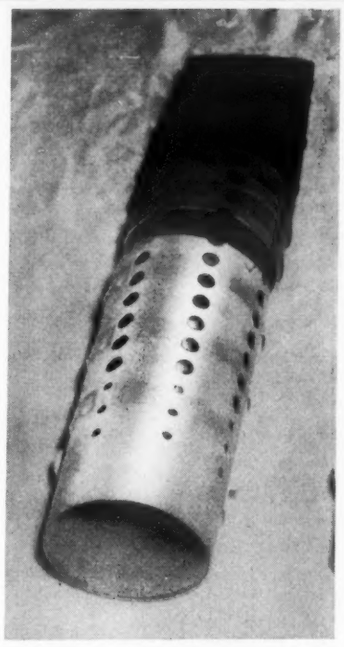

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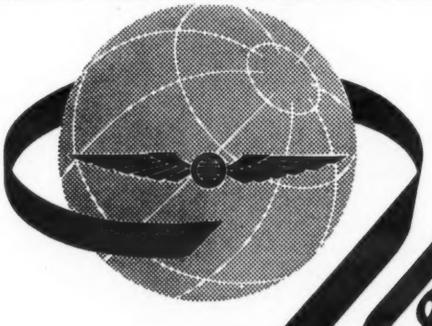

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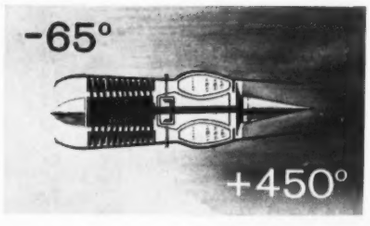

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